A PRELIMINARY INVESTIGATION OF AURAL INPUT/OUTPUT SYSTEMS FOR IN-FLIGHT INFORMATION RETRIEVAL

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Monterey, California

THESIS

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AURAL INPUT/OUTPUT SYSTEMS FOR
IN-FLIGHT INFORMATION RETRIEVAL

by

Albert George Mertz

September 1978

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An analysis of two commercially available Speech Understanding Systems (SUS) was conducted. Each system was tested against various background noise conditions. Results obtained were compared with current criteria for SUS application in aircraft. Additionally, since the P-3 Orion aircraft is being considered as a SUS test aircraft, a survey of Fleet P-3 pilots was conducted. Their opinion was sought on what a SUS equipped microprocessor should be capable of accomplishing as an aid to the flight crew.

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A Preliminary Investigation of
Aural Input/Output Systems for
In-Flight Information Retrieval

by

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Lieutenant, United States Navy
B.S., United States Naval Academy, 1969

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

An analysis of two commercially available Speech Understanding Systems (SUS) was conducted. Each system was tested against various background noise conditions. Results obtained were compared with current criteria for SUS application in aircraft. Additionally, since the P-3 Orion aircraft is being considered as a SUS test aircraft, a survey of Fleet P-3 pilots was conducted. Their opinion was sought on what a SUS equipped microprocessor should be capable of accomplishing as an aid to the flight crew.

TABLE OF CONTENTS

LIST OF FIGURES

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LCDR Richard M. Fifer
LT Gary G. Maxwell
LT Jon A. Buresh

Special thanks must also go to Mr. Paul Sparks, the Technician at the Human Factors Laboratory, Naval Postgraduate School. Mr. Sparks hand built from kits the IMSAI 8080 and all controlling Input/Output boards required for operation of the microprocessor. He also contributed freely of his time and technical expertise in solving problems encountered during interfacing system components. His personal involvement was a significant factor in the success of this experiment.

I. INTRODUCTION

Recent years have seen a remarkable advance in aircraft technology, along with a corresponding increase in aircraft complexity and pilot workload. Since a high pilot workload has always been associated with a high aircraft accident rate, it is most desirable to find some means of reducing pilot workload as much as possible.

One possible answer lies in the area of Speech Understanding microprocessor systems. These would allow the pilot of an aircraft so equipped to verbally command a microprocessor system which in turn would cause the aircraft to follow the pilot's instructions, such as a climb or descent to a specified altitude. The pilot might also request information from the computer, such as a Maximum range profile or to display the appropriate emergency checklist as required. Voice communication with the computer would free the pilot of the necessity of keying in instructions as current technology requires.

Speech Understanding Systems (SUS) have experienced rapid advancement in recent years also, with both government and private industry sponsored programs being undertaken. Reference 1 focuses on the operational military applications of Speech Understanding Systems and provides an overview of the nontechnical factors in the military environment which are likely to affect the introduction of SUS capabilities in military systems.

Microprocessor hobbyists have also developed systems not only for speech understanding but speech synthesis as well. Two such systems were available at the Naval Postgraduate School through the Human Factors Engineering Lab. Heuristics, Inc. had developed a system called SPEECHLAB for speech understanding, and Computalker Consultants had developed COMPUTALKER for speech synthesis.

Both systems have advantages which make them particularly applicable to aircraft cockpit design. They are both small in physical size and require less than 6K of RAM for their controlling programs. Vocabulary size dictates the actual amount of RAM required by each system, with 5K being adequate for a 16 word vocabulary in the SPEECHLAB system. The COMPUTALKER system, as currently structured, allows the user to encode words or phrases, according to phonetic spelling rules, in up to 76 characters at a time. Since the average word requires less than 15 such characters, phrases of approximately four words could easily be constructed. The main advantage of the COMPUTALKER system is that many such phrases could be stored in available memory, loaded as required into the COMPUTALKER input buffer area, and quickly output as recognizable speech. This eliminates the requirement for a complicated algorithm to assemble prestored words into phrases, thus saving valuable memory area. The current COMPUTALKER input buffer requires approximately 2½K of memory for encoding the 76 characters. Both systems are relatively inexpensive, with current models available for under $300 in kit form. [Ref. 2 and 3]

This study was undertaken to determine the performance of each system as well as the possibility of incorporation in an aircraft cockpit control system. Specific goals were:

1) Determine response time and accuracy of SPEECHLAB under low background noise level conditions.
2) Determine the recognizability of COMPUTALKER under low background noise conditions.
3) Repeating goals 1) and 2) with varying levels of background noise intensity to determine the limiting tolerance of each system to background interference.

Current studies being carried on by the Navy indicate the possible use of the P-3 Orion aircraft as a test bed for voice controlled cockpit systems [Ref. 4]. With this in mind, a survey of Fleet P-3 pilots was conducted to determine their reaction of the possible incorporation of such a voice controlled system in the P-3. The survey questions used are listed in Appendix C. The answers to the questions are discussed in the Results and Conclusions section of this report.

II. DESCRIPTION OF APPARATUS

A. SPEECHLAB

The SPEECHLAB hardware, manufactured by Hueristics, Inc., Los Altos, California, is compatible with the 8080 microprocessor developed by Intel and employs the S100 bus [Fig. 1].

Audio input is amplified and passed through three band pass filters encompassing the range from 150 to 900 Hz, 900 Hz to 2.2 KHz, and 2.2 to 5 KHz. These ranges roughly correspond to the first three resonances of the human vocal tract. A zero-crossing detector generates a voltage proportional to the number of times the raw waveform crosses the rest level in a given period of time. The signal is then passed to a six-bit A/D converter. The output of this A/D converter is fed directly onto the computer data bus.

The controlling software programs utilized in this experiment were taken from the manual supplied with the SPEECHLAB board and modified for use on the Human Factor Engineering Labs' 8080 microprocessor. Investigations conducted prior to commencement of the experiment showed the algorithm which used Euclidian distance measure to be the most accurate of the programs in the manual. Of the most importance in this particular program was the variable S, which represented the number of divisions into which the speech utterance would be divided in order to be analyzed by the program. This parameter, set at 64 as provided, was shown to have the greatest effect on

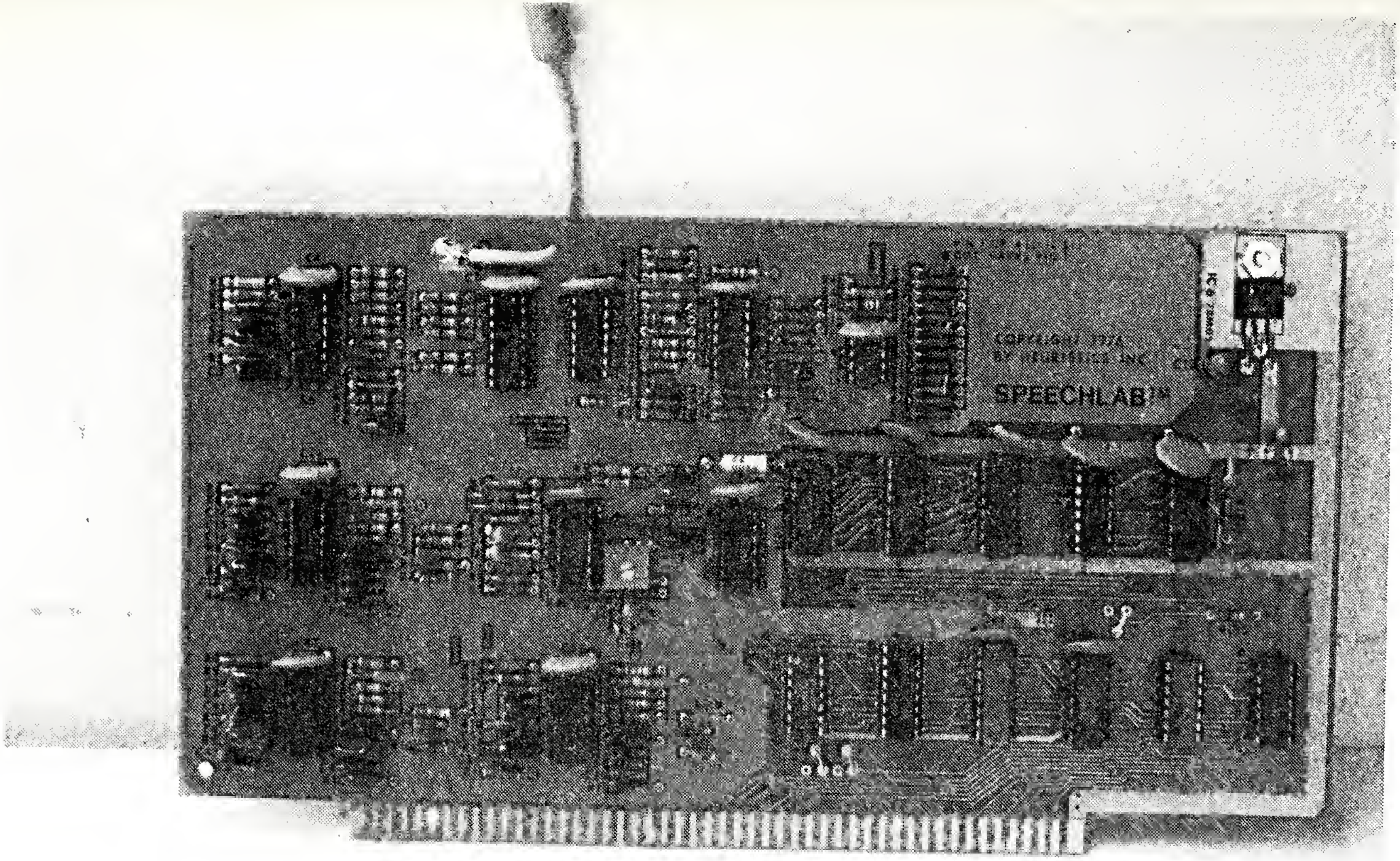

Figure 1. SPEECHLAB Hardware Board

response time. Response time was measured from the closing of the speech window to the time the machine began to type the recognition message on the teletype. The speech window width as set by the algorithm was approximately 2.5 sec in duration. This is a variable and could be changed by the operator. The beginning of the speech window was signaled by a beep at the microphone in use. A similar beep signaled the close of the window [Ref. 5]. The Basic and controlling programs used by speech lab are included as Appendix A.

B. COMPUTALKER

The COMPUTALKER hardware was developed by Computalker Consultants, of Santa Monica, California [Fig 2].

The COMPUTALKER board is controlled by CSR1, a software program provided with the system. CSR1 is a phoneme-input speech synthesizer program. It contains definitions in the form of various table entries for 55 different input symbols which represent the phonemes of the English language along with several punctuation marks. CSR1 accepts a phonetic input string consisting of these phonemes and punctuation symbols and decimal digits which specify vowel stress levels. This input string is parsed to fill out a phonetic feature matrix for the desired synthetic phrase. A set of phonetic structure rules scans the matrix to look for feature patterns and combinations which must be adjusted to conform to English pronunciation. After these adjustments, a parameter generator algorithm scans the matrix and produces the control parameters needed to operate

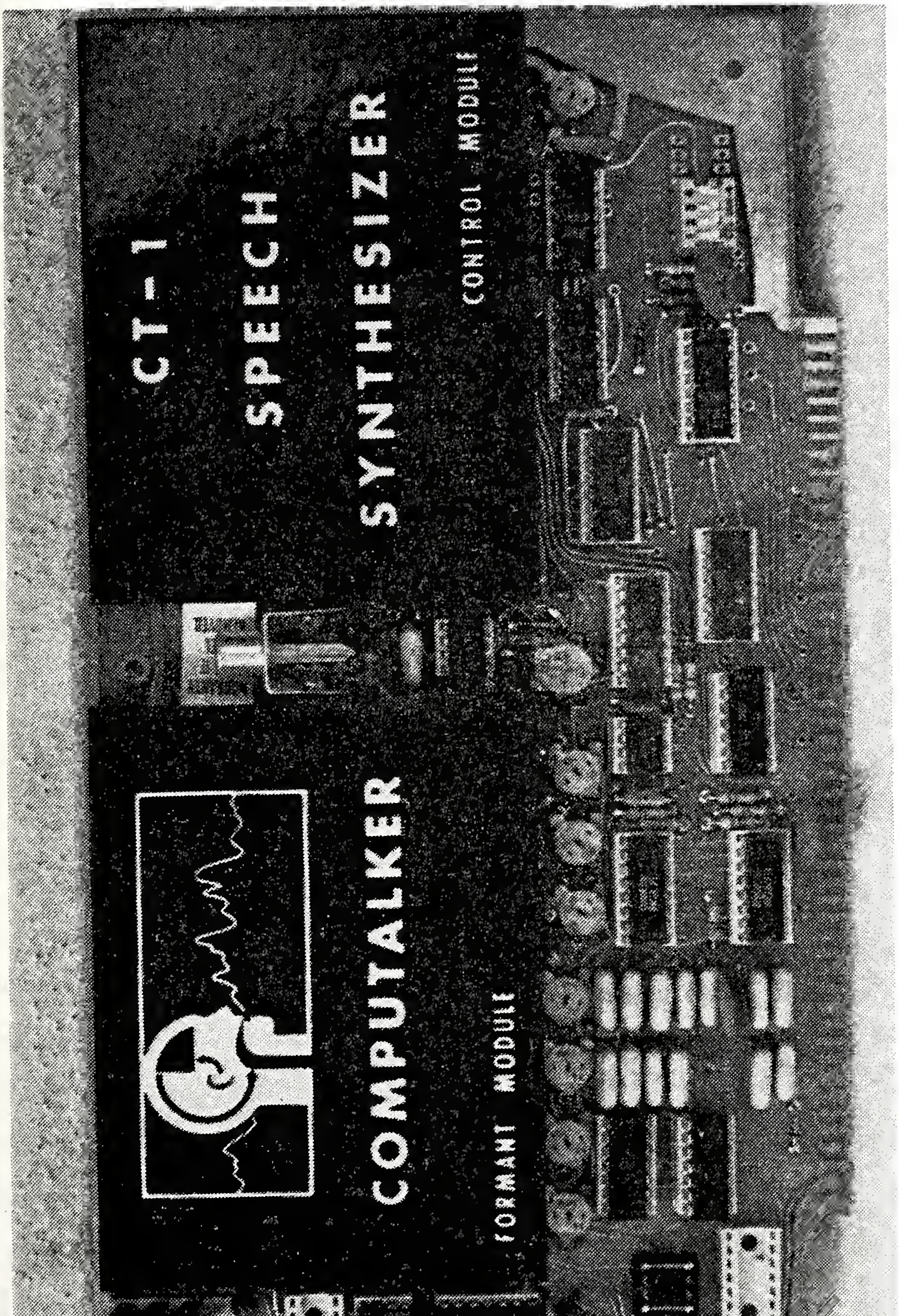

Figure 2. COMPUTALKER Hardware Board

the COMPUTALKER Synthesizer [Ref 6]. The COMPUTALKER board is shown in Figure 2. The CSR1 program is included as Appendix B.

C. SOUND LEVEL METER

The sound level meter used during the experiment was the General Radio Corporation, Type 1565-B. The range of the instrument was from 40 dB to 140 dB, referenced to 20 micro Newtons per square meter. Unless otherwise noted, all sound pressure level measurements in this experiment were made with this sound level meter. The meter also provided for the use of three different weighting levels, A, B, or C, which conform to ANSI S1.4-1971 Type 2 and IEC 123,1961 specifications. Weighting C was chosen for use in this experiment as it provided the flatter response curve over a wider range of frequencies than either of the other weightings [Fig. 3].

D. MAICO AUDIOMETER

The MAICO Dual Channel Research and Diagnostic Audiometer, Model MA-24B, was used to provide the background noise and pure tones used during the course of this investigation. The Hearing Threshold Level in each channel could be controlled accurately through the range from -3 dB to 112 dB. This equated to a range of from 47 dB to 162 dB when referenced to 20 micro Newtons per square meter [Fig. 4].

E. MICROPROCESSOR

The microprocessor used for the experiments was built from a kit manufactured by IMSAI Corporation. The basic kit utilizes

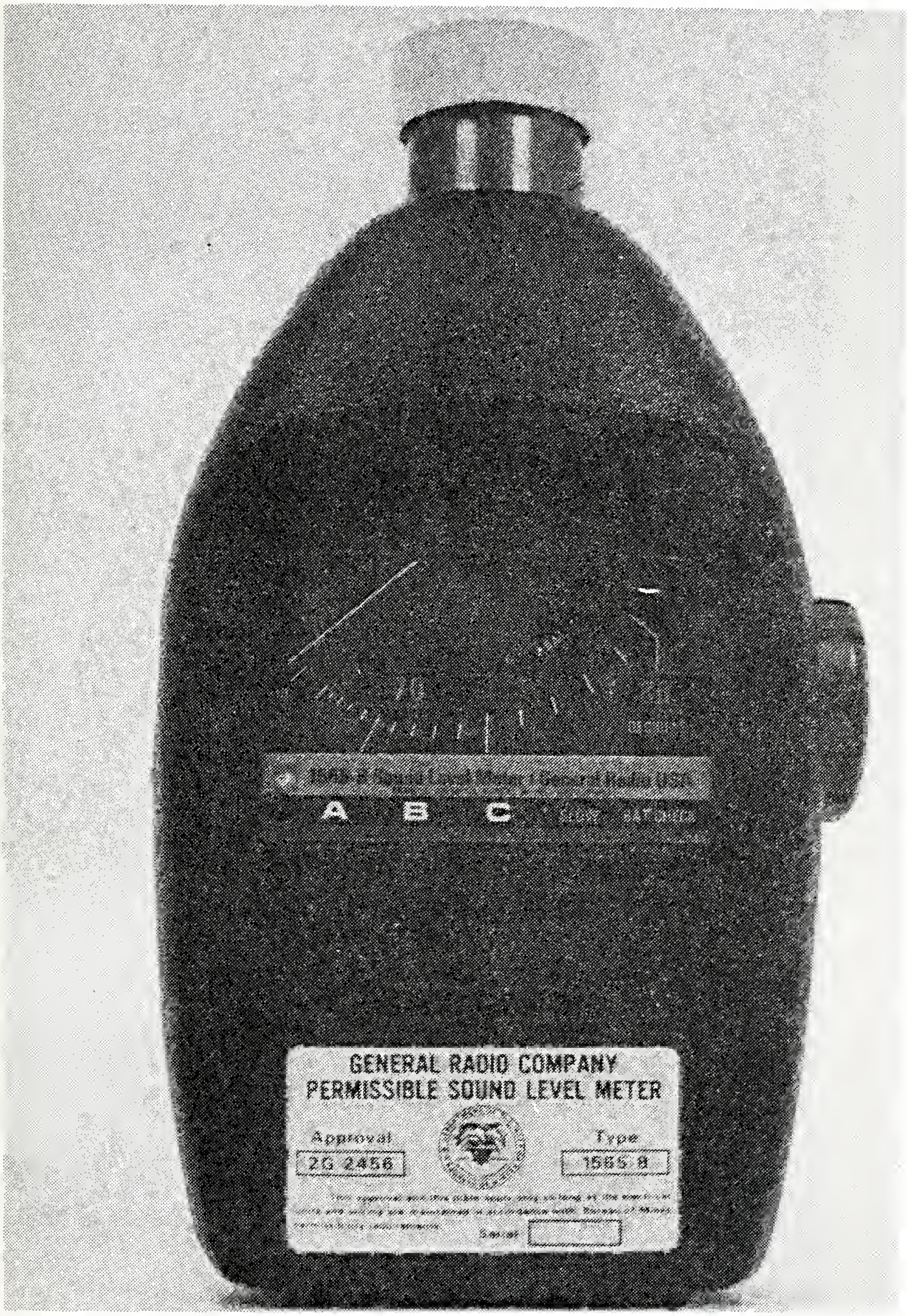

Figure 3. Sound Level Meter

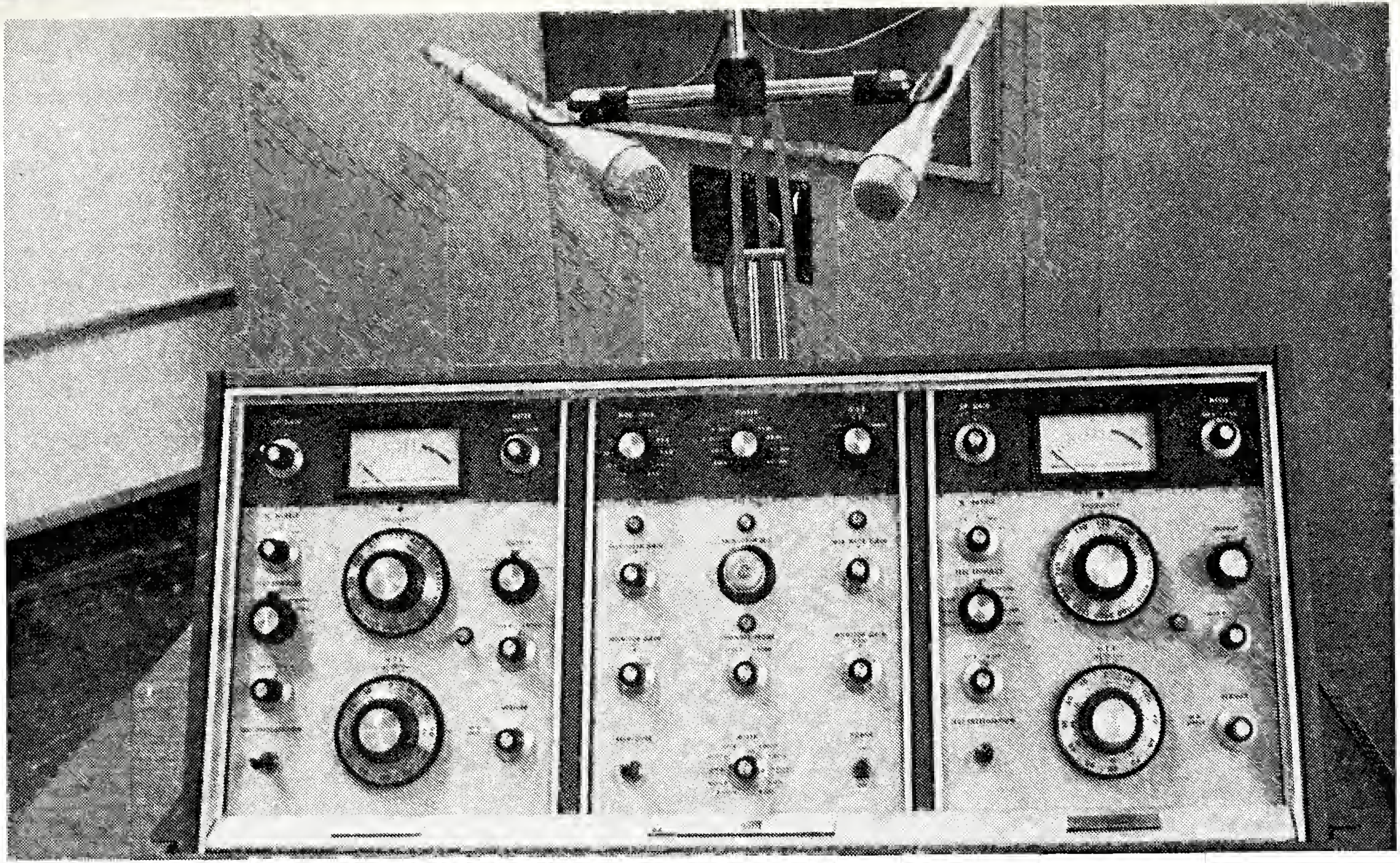

Figure 4. Audiometer

the INTEL 8080 microprocessor chip and standard INTEL 8080 instructions. An IMSAI Multiple Input/Output board was used for input/output. Memory available included 4K of PROM and 32K of RAM. Sufficient space was available for up to 32K additional memory, assuming the same type of memory packaging. Figure 5 shows the 8080 microprocessor with the SPEECHLAB, COMPUTALKER, memory and I/O boards installed.

Figure 6 shows the Audiometer and Microprocessor set up outside the test booth. The microprocessor was controlled with a standard teletype keyboard. Figure 7 shows the interior of the test booth. All inputs to the booth were channeled through the patch box on the right of the table. The microphone stand had full freedom of motion which allowed the subjects to position the microphone within one inch of their lips while speaking. The speakers used to introduce noise, tones and the COMPUTALKER speech are located in the rear of the booth.

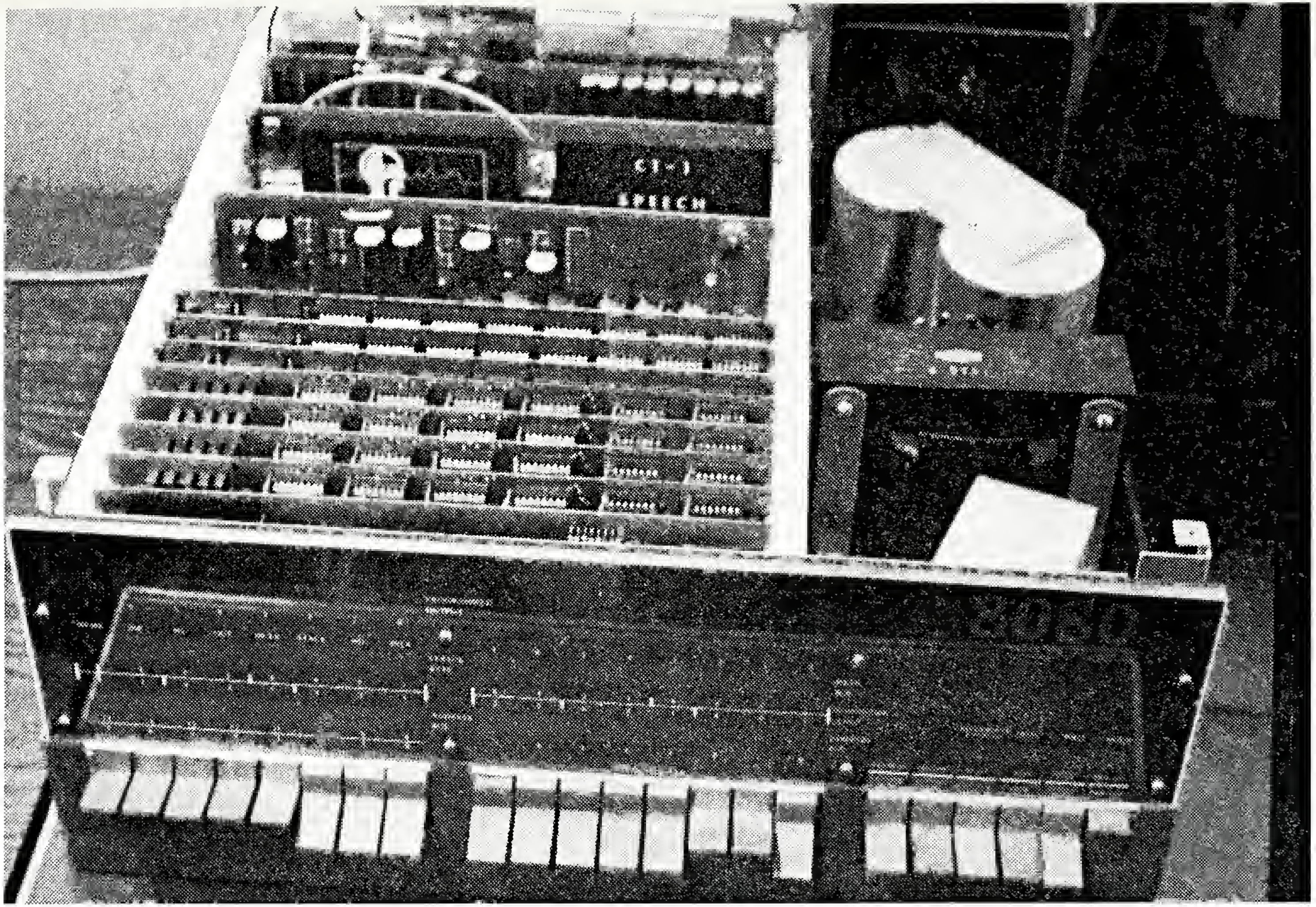

Figure 5. 8080 Microprocessor with SPEECHLAB and COMPUTALKER installed

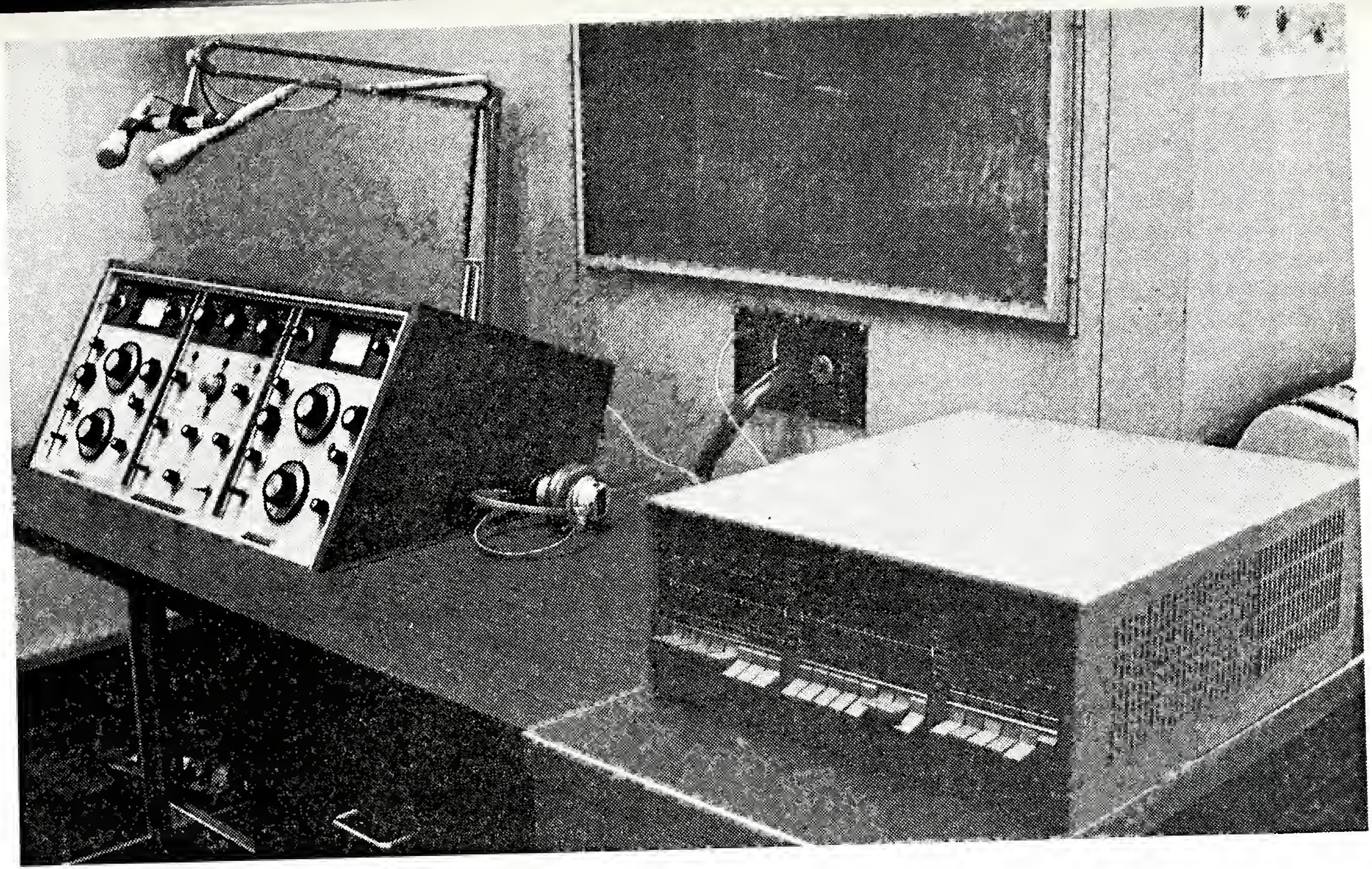

Figure 6. Audiometer and Microprocessor Outside Test Booth

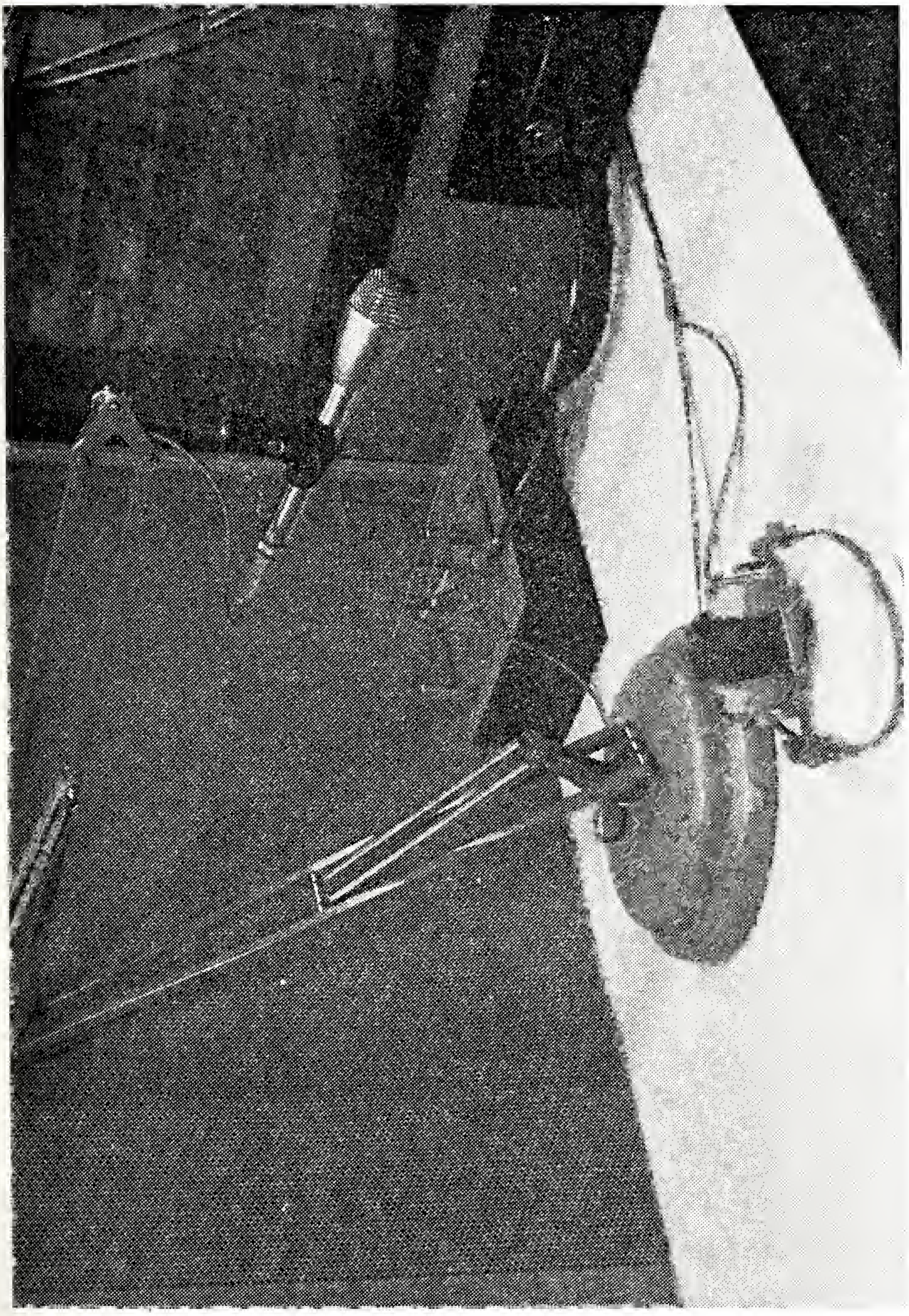

Figure 7. Microphone Setup Inside Test Booth

III. EXPERIMENTAL PROCEDURE

All experiments were conducted at the Human Factors Engineering Laboratory at the Naval Postgraduate School.

A. SPEECHLAB TESTING

For the voice recognition tests, each subject trained the SPEECHLAB unit on the ten word vocabulary selected from Ref. 1. No background noise was introduced into the booth in which the subjects operated from. Noise level in the booth under these conditions was measured at 40 dB using the sound level meter. After training, the performance mode of the system was entered. Background noise level remained at 40 dB for the tests. The subject was required to read through the word list, in order, five times, thus obtaining fifty samples of speech utterances from each subject per test. Each test was repeated three times, with the S parameter of the SPEECHLAB algorithm set at 64, 32, and 16. This was done to test the performance of the algorithm with varying sample sizes. Typical results are shown in Figure 8.

Next, various background noise levels were introduced in the booth to determine system response to noise. The subjects followed the same procedures as in the no-noise tests. The S parameter remained set at 64 throughout the tests as this was determined to be the most accurate mode for SPEECHLAB. Background noise level was raised in 5 dB increments from 60 dB to

DATE 17 Aug 78

SUBJECT Buresh

SPEECHLAB X S 64

COMPUTALKER ___

PROGRAM 1

BACKGROUND NOISE 40 dB

FREQUENCY --

TIME (AVERAGE) 27 sec

S \ R	1	2	3	4	5	6	7	8	9	0
1	5									
2		5								
3		2							3	
4				5						
5					5					
6						4	1			
7							4		1	
8								5		
9									5	
0										5

Total $\frac{43}{50} = 0.86$

WORD LIST

1) ALTITUDE
2) SPEED
3) HEADING
4) POSITION
5.) TACAN
6) VOR
7) ILS
8) GLIDESLOPE
9) CLIMB
0) DESCEND

Figure 8. Typical Results of SPEECHLAB Tests (with low background noise)

80 dB. However, in no test was the SPEECHLAB system able to accomodate more than 74 dB. Typical results for this series of tests are shown in Figure 9.

To test the effect of frequency on the SPEECHLAB system, pure tones ranging from 4000 Hz to 8000 Hz were induced and the tests repeated by the subjects. Incremental tone steps were 1000 Hz. Typical test results are shown in Fig. 10. A summary of results from the SPEECHLAB tests is presented in Fig. 11.

B. COMPUTALKER TESTING

To test the accuracy with which COMPUTALKER produced speech, the same word list used for the SPEECHLAB tests was prepared for use with COMPUTALKER. Each word on the list was rearranged according to the phonetic spelling rules used by COMPUTALKER. Various combinations of phonetic spellings were tried until an acceptable utterance was produced. This list of words, which were now optimized to the principal researcher, was then presented to each of the subjects. Re-optimization, where necessary, was done until each subject readily recognized each word on the list. The word list and final phonetic spelling was as follows:

(1) ALTITUDE -- AH2LTTIYTUX3D

(2) SPEED -- SHPQIY3DX

(3) HEADING -- HHEHDIYNGX

(4) POSITION -- POHSIH1SSIYOHN

(5) TACAN -- TAE3QKAAN

DATE 11 Aug 70

SUBJECT Fifer

SPEECHLAB X S 32

COMPUTALKER ___

PROGRAM ___

BACKGROUND NOISE 65 dB

FREQUENCY --

TIME (AVERAGE) 26 sec

S \ R	1	2	3	4	5	6	7	8	9	0
1	3		1							
2		2	3							
3			3		1		1			
4		4		1						
5	3		1						1	
6		2	3							
7	1		3			1				
8	1		1					3		
9		1	4							
0				3			2			

Total $\frac{12}{50} = 0.24$

WORD LIST

1) ALTITUDE
2) SPEED
3) HEADING
4) POSITION
5) TACAN
6) VOR
7) ILS
8) GLIDESLOPE
9) CLIMB
0) DESCEND

Figure 9. Typical Results of SPEECHLAB Tests (with various noise levels)

DATE 22 Aug 78

SUBJECT Buresh

SPEECHLAB X S 64

COMPUTALKER ___

PROGRAM 1

BACKGROUND NOISE 75 dB

FREQUENCY 4000 Hz

TIME (AVERAGE) 28 sec

S \ R	1	2	3	4	5	6	7	8	9	0
1	3		1						1	
2	1	4								
3			4						1	
4			2	3						
5				1	4					
6		1				4				
7							5			
8								5		
9			1						4	
0										5

Total $\frac{41}{50} = 0.82$

WORD LIST

1) ALTITUDE
2) SPEED
3) HEADING
4) POSITION
5.) TACAN
6) VOR
7) ILS
8) GLIDESLOPE
9) CLIMB
0) DESCEND

Figure 10. Typical Results of SPEECHLAB Tests (with various tone levels)

	NO BACKGROUND NOISE (1)			BACKGROUND NOISE (2)				BACKGROUND TONE (3)				
	S			dB				Hz				
SUBJECT	64	32	16	60	65	70	74	4K	5K	6K	7K	8K
1	100	84	58	86	70	42	37	100	98	82	92	90
2	76	46	32	32	24	33	20	76	72	72	72	70
3	86	78	52	78	60	37	27	82	86	86	80	80
4	90	82	60	82	60	30	24	80	82	75	75	78
AVERAGE	88	72.5	50.5	69.5	53.5	35.5	27	84.5	84.5	78.8	79.8	79.5

(1) With no noise input to the test booth, the noise level inside the booth was measured to be 40 dB.

(2) Background noise was broadband white noise.

(3) Pure tones were input at 75 dB.

Figure 11. Summary of Results from SPEECHLAB Testing

(6) VOR -- VVIY1, OH1UW, REH1R

(7) ILS -- AY1, ELL, SS

(8) GLIDESLOPE -- GXLAY3DSLUHP

(9) CLIMB -- KLAY1MB

(0) DESCEND -- DIYSEHND

The phonetic spelling rules used by COMPUTALKER are shown in Fig. 12.

Consonants		
P	p	pie
T	t	tie
K	k	key
B	b	by
D	d	die
G	g	guy
M	m	my
N	n	nigh
NX	ŋ	hang
F	f	fie
V	v	vie
TH	θ	thigh
DH	ð	thy
S	s	sigh
Z	z	zoo
SH	ʃ	shy
ZH	ʒ	vision
L	l	lie
W	w	we
R	r	rye
Y	j	you
HH	h	high
CH	tʃ	chime
JH	dʒ	jive
WH	wʰ	why
EL	l̩	battle
EM	m̩	bottom
EN	n̩	button
Q	ʔ	(glottal stop)

Vowels		
IY	i	heed
IH	ɪ	hid
EY	eɪ	hayed
EH	ɛ	head
AE	æ	had
AA	ɑ	hod
AO	ɔ	hawed
OW	oʷ	hoed
UH	ʊ	hood
UW	uʷ	who'd
ER	ɚ	herd
AH	ʌ	Hudd
AY	aɪ	hide
AW	aʷ	how
OY	ɔɪ	boy
AX	ə	about
IX	ɨ	David
OH	o	core
UX	u	too

Punctuation	
space	word boundary
,	pause/silence
.	falling pitch
?	rising pitch
return	end of input

Stress Marks	
Ø	no stress
1	primary (max) stress
2	secondary stress
3	tertiary stress
4	etc.
5	
> 5	no stress

Several other symbols are used internally by certain rules. These may also be used in the input string.

KX	coo	(K before back vowel)
GX	goo	(G before back vowel)
RX	card	(R after a vowel)
LX	kill	(L after a vowel)
DX	pity	(T between vowels)
YX		diphthong ending
WX		diphthong ending

Table 1 CSR1 Phonetic Input Symbols

Stress marks may be placed on any vowel in the form of a following digit from 5 (weakest stated stress) to 1 (maximum stress). Any stress digit greater than 5 will be ignored. Ending an input string with a period or question mark has the effect of changing the ending pitch, falling or rising, respectively. A comma has no effect on the pitch, but only introduces a pause in the pronunciation.

Figure 12. COMPUTALKER Phonetic Spelling Rules

IV. RESULTS AND CONCLUSIONS

A. SPEECHLAB

Results from the SPEECHLAB tests showed that while the performance approximated what the manufacturers claim, i.e., acceptability percentage in the high nineties, any significant amount of background noise causes a marked deterioration in its performance. Above 74 dB, the algorithm would not accept speech utterances at all, rather signaling "SPEECH OUT OF WINDOW", indicating that it thought the noise was the speech utterance.

An attempt was made to improve the performance of the algorithm by training it with the background noise set at 62 dB. While this did improve the recognition rate of the program with the background noise level at 60 and 65 dB, performance again fell off rapidly at 70 dB and at 74 dB the algorithm again could not distinguish the speech from the background noise.

A noise cancelling boom mike would almost certainly have improved the performance of the system, as would the wearing of an oxygen mask. However, as noted by previous researchers [Ref. 7], the background noises induced by heavy breathing under moments of stress and high G interfere greatly with a speech recognition system's performance.

The response time for the most accurate algorithm, i.e., with S set at 64, was judged to be unacceptable, averaging out to 27 sec in all tests. However, with the S parameter set at

16, the average response time was 9 sec, a slightly high but possibly acceptable time [Ref. 8]. The system accuracy in this case dropped to just slightly more than 50%, clearly unacceptable.

Obviously, the algorithm provided with the SPEECHLAB hardware requires a great deal of improvement. If this is not possible, and none of the improvements suggested by the SPEECHLAB manual [Ref. 9] produce noticeable improvement, a completely new algorithm must be found before the SPEECHLAB system could be considered acceptable for military use. Further testing should also include vibration levels of various intensities to simulate aircraft motion.

Two observations made during the course of the experiment suggest, however, that the low recognition rates obtained may not be due entirely to the algorithms used.

First, it was noted that as a subject became more used to "talking" to the machine, a slight improvement in the algorithm's recognition rate was seen. It appears that the subject began to pronounce the words on the list in a more consistent manner after numerous repetitions. This was especially true when the subject was told that a successful recognition had been achieved. This appeared to reinforce in the subject's mind the particular pronunciation which produces the successful recognition. If the subjects had been trained in this manner prior to commencement of the testing, the initially lower recognition rates might have been avoided. It would seem therefore that operator training would play a significant role in any successful voice recognition system.

The second observation concerned the day-to-day changes that occur in the human voice. On one occasion, a subject reported for testing with a cold which had changed the tone of his voice considerably. Although this particular subject had enjoyed one of the highest recognition rates of the group (in the middle nineties), on this particular day his recognition rate fell to just below 80%. No other subject was tested with any other ailment, but it is felt that such things as a sore throat, asthma or other allergic reactions which changed the tone of the voice would cause a similar drop in the system performance.

The obvious conclusion to be drawn here is that some means must be developed, whether through software programming or hardware devices, to account for possible daily changes in an operator's voice characteristics.

Several attempts were made to train the SPEECHLAB algorithm with one subject and test it with another person speaking. The results were so poor that, in general, it appears impractical with the present system to attempt to use it in such a manner. As presently set up, the best method to use the system with more than one person would be to train the algorithm with each person's voice. This would, of course, require more storage space and greatly increase recognition time.

B. COMPUTALKER

The results from the COMPUTALKER testing were unique in that after initial presentation of the word list, all subjects scored 100% on all tests. Although the initial recognition

rate during the optimization testing was very low (20%), the subjects rapidly related the machine speech with the proper word. Changing background noises and tone had almost no effect on the tests. The only area of difficulty encountered was due to the nature of the white noise introduced to the testing chamber. The sound produced by the noise is best described as a hiss, which is very similar to the letter "S" as pronounced by COMPUTALKER. This had the effect of masking the letter "S" when the machine spoke the word "ILS". All subjects, however, were able to hear the "IL" part of the word with no trouble and correctly deduced the word to be "ILS".

At this point in the experiment, the testing procedure was modified since the vocabulary under consideration was obviously too small, allowing the subjects to easily determine the correct choice by process of elimination. Another ten words were added to the vocabulary and optimized as before. The additional words and their phonetic spelling were as follows:

(11) ABOVE -- AHBAHOHV

(12) BELOW -- BIY3LOW2

(13) CHECK -- CHEHK

(14) DOWN -- DAOWHN

(15) ENGINE -- EHNJHIHN

(16) FIRE -- FQAY1R

(17) GEAR -- GEHER

(18) NAVIGATION -- NAE1VEHGEY1SOHN

(19) PRESSURE -- PREHSUHR

(20) SOME -- SQEMN

Various combinations of ten words from the twenty word vocabulary were chosen and presented to the subjects. Although results were expected to be poor, the opposite was true. Only one subject missed one word. However, all expressed the opinion that they had had a much more difficult time in determining the correct word. This would infer that they thought about their choice much longer than required before. This is obviously undesirable, as a pilot can usually ill afford to have his attention drawn away from the task of flying his aircraft. One solution to this problem would be to limit the machine's vocabulary to twenty words or less, but this might not be feasible in all situations.

One method of increasing the vocabulary size that could be used with the COMPUTALKER system would be to improve the quality of the sounds produced by the governing phonetic spelling rules. It was noted throughout the course of the experiments that the sounds produced by COMPUTALKER were not quite what was expected from the description in the phonetic rules [Fig. 12]. Most sounds were close enough that the subjects readily adjusted to them with little or no difficulty. Some letters of the alphabet were difficult to recognize, as was noted previously about the letter "S", the sound in this case being more of a hiss than the "es" sound normally associated with the letter. Also, COMPUTALKER produced soft sounds much more readily than hard ones, most notably at the end of a word. For example, the word "CHECK" is pronounced more like "cheg" by the system. Although this was a minor

problem in this instance, incorporation of the word "CHECK" in certain phrases may lead to ambiguous meanings due to its mispronunciation.

Correcting the sounds produced by the phonetic rules used by the system would involve changing the computer code which controls the COMPUTALKER hardware. These rules are contained in Sections 2 through 6 of the CSR1 Source listing. Due to time constraints, no such improvements were attempted, but are considered to be necessary to upgrade the quality of the COMPUTALKER system.

C. SURVEY

The general results of the survey, while not conclusive, indicate that most of the pilots would prefer the computer be used to calculate such things as Weight and Balance, Proven Limit of Endurance profiles (PLE), Maximum Range profiles, etc. Many felt it would be advantageous to have the computer warn the pilots of impending failures of systems or emergencies, such as slowly falling oil pressure, increasing temperatures in engine sections, etc. Several pilots favored a verbal warning from the computer, in addition to the normal indications, in the case of an approach to landing with the gear still up.

Few pilots indicated a willingness to allow the computer to actually take physical control of the aircraft under any circumstance, although a few would have allowed the computer to do so with the pilot's explicit approval. The latter would allow the computer to suggest an appropriate course of action

and, if it met with the pilot's approval, give permission to carry out the procedure. Interestingly, many pilots expressed concern that a computer system of this type would be detrimental to the morale of the Flight Engineer and cause complacency among the pilots themselves. A few pilots were even of the opinion that the autopilot, while of great benefit on long transit flights, was causing complacency and reduced flying skills among some pilots.

It would seem from the general reaction of most pilots that the initial flight testing and operational experience of a SUS be conducted at the TACCO and Navigator stations aboard the aircraft, as indicated by Ref. 4.

APPENDIX A

SPEECHLAB COMPUTER PROGRAMS

The controlling program for SPEECHLAB is written in BASIC. The SPEECH Driver requires modifications be made to the BASIC system being used. In order to save space, Hueristics, Inc., decided to use the Palo Alto TINY BASIC system, developed by Dr. Li-Chen Wang. TINY BASIC handles only interger numbers, but this is not a major problem in the SPEECHLAB program. TINY BASIC, the required modifications for the SPEECHLAB Driver, and the SPEECHLAB controlling programs are reproduced on the following pages with the permission of Hueristics, Inc.

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**************************************************************
*
*                TINY BASIC FOR INTEL 8Ø8Ø
*                      VERSION 1.Ø
*                    BY LI-CHEN WANG
*                     1Ø JUNE, 1976
*                       @COPYLEFT
*                  ALL WRONGS RESERVED
*
**************************************************************
*
*  *** ZERO PAGE SUBROUTINES ***
*
*  THE 8Ø8Ø INSTRUCTION SET LETS YOU HAVE 8 ROUTINES IN LOW
*  MEMORY THAT MAY BE CALLED BY RST N, N BEING Ø THROUGH 7.
*  THIS IS A ONE BYTE INSTRUCTION AND HAS THE SAME POWER AS
*  THE THREE BYTE INSTRUCTION CALL LLHH.  TINY BASIC WILL
*  USE RST Ø AS START OR RESTART AND RST 1 THROUGH RST 7 FOR
*  THE SEVEN MOST FREQUENTLY USED SUBROUTINES.
*  TWO OTHER SUBROUTINES (CRLF AND TSTNUM) ARE ALSO IN THIS
*  SECTION.  THEY CAN BE REACHED ONLY BY 3-BYTE CALLS.
*
                        ORG  X'ØØØØ'
ØØØØ F3           START DI   ,        *** START/RESTART ***
ØØØ1 31ØØ2Ø @@@@        LODI SP,STACK INITIALIZE THE STACK
ØØØ4 C3BAØØ             JMP  ST1      GO TO THE MAIN SECTION
ØØØ7 4C                 CHAR 'L'
*
ØØØ8 E3                 XCH  HL,(SP)  *** TSTC OR RST 1 ***
ØØØ9 EF                 IGNBLK        IGNORE BLANKS AND
ØØØA BE                 CMP  M        TEST CHARACTER
ØØØB C368ØØ             JMP  TC1      REST OF THIS IS AT TC1
*
ØØØE 3EØD         CRLF  LODI A,@CR    *** CRLF ***
*
ØØ1Ø F5                 PUSH AF       *** OUTC OR RST 2 ***
ØØ11 3AØØØ8             LD   A,OCSW   PRINT CHARACTER ONLY
ØØ14 B7                 IOR  A        IF OCSW SWITCH IS ON
ØØ15 C31AØ7             JMP  OC2      REST OF THIS IS AT OC2
*
ØØ18 CD55Ø4             CALL EXPR2    *** EXPR OR RST 3 ***
ØØ1B E5                 PUSH HL       EVALUATE AN EXPRESION
ØØ1C C311Ø4             JMP  EXPR1    REST OF IT IS AT EXPR1
ØØ1F 57                 CHAR 'W'
*
ØØ2Ø 7C                 LOD  A,H      *** COMP OR RST 4 ***
ØØ21 BA                 CMP  D        COMPARE HL WITH DE
ØØ22 CØ                 RET  NZ       RETURN CORRECT C AND
ØØ23 7D                 LOD  A,L      Z FLAGS
ØØ24 BB                 CMP  E        BUT OLD A IS LOST
ØØ25 C9                 RET  U
ØØ26 414E               CHAR 'AN'
*
ØØ28 1A           SS1   LD   A,(DE)   *** IGNBLK/RST 5 ***
ØØ29 FE2Ø               CMPI ' '      IGNORE BLANKS
ØØ2B CØ                 RET  NZ       IN TEXT (WHERE DE->)
ØØ2C 13                 INC  DE       AND RETURN THE FIRST
ØØ2D C328ØØ             JMP  SS1      NON-BLANK CHAR. IN A
*
ØØ3Ø F1                 POP  AF       *** FINISH/RST 6 ***
```

```
ØØ31 CD91Ø5                     CALL PIN       CHECK END OF COMMAND
ØØ34 C3A4Ø5                     JMP  QWHAT     PRINT "WHAT?" IF WRONG
ØØ37 47                         CHAR 'G'
*
ØØ38 EF                         IGNBLK         *** TSTV OR RST 7 ***
ØØ39 D64Ø                       SUBI '@'       TEST VARIABLES
ØØ3B D8                         RET  C         C:NOT A VARIABLE
ØØ3C C258ØØ                     JMP  NZ,TV1    NOT "@" ARRAY
ØØ3F 13                         INC  DE        IT IS THE "@" ARRAY
ØØ4Ø CDFBØ4                     CALL PARN      @ SHOULD BE FOLLOWED
ØØ43 29                         ADD  HL,HL     BY (EXPR) AS ITS INDEX
ØØ44 DA9FØØ                     JMP  C,QHOW    IS INDEX TOO BIG?
ØØ47 D5                         PUSH DE        WILL IT OVERWRITE
ØØ48 EB                         XCH  HL,DE     TEXT?
ØØ49 CD3DØ5                     CALL SIZE      FIND SIZE OF FREE
ØØ4C E7                         COMP           AND CHECK THAT
ØØ4D DADØØ5                     JMP  C,ASORRY  IF SO, SAY "SORRY"
ØØ5Ø 21ØØ1F @@@@                LODI HL,VARBGN IF NOT, GET ADDRESS
ØØ53 CD6ØØ5                     CALL SUBDE     OF @(EXPR) AND PUT IT
ØØ56 D1                         POP  DE        IN HL
ØØ57 C9                         RET  U         C FLAG IS CLEARED
ØØ58 FE1B                TV1    CMPI 27        NOT @, IS IT A TO Z?
ØØ5A 3F                         CMC  ,         IF NOT RETURN C FLAG
ØØ5B D8                         RET  C
ØØ5C 13                         INC  DE        IF A THROUGH Z
ØØ5D 21ØØ1F @@@@                LODI HL,VARBGN COMPUTE ADDRESS OF
ØØ6Ø Ø7                         ROT  L         THAT VARIABLE
ØØ61 85                         ADD  L         AND RETURN IT IN HL
ØØ62 6F                         LOD  L,A       WITH C FLAG CLEARED
ØØ63 3EØØ                       LODI A,Ø
ØØ65 8C                         ADC  H
ØØ66 67                         LOD  H,A
ØØ67 C9                         RET  U
*
*                        TSTC   XCH  HL,(SP)   *** TSTC OR RST 1 ***
*                               IGNBLK         THIS IS AT LOC. 8
*                               CMP  M         AND THEN JMP HERE
ØØ68 23                  TC1    INC  HL        COMPARE THE BYTE THAT
ØØ69 CA73ØØ                     JMP  Z,TC2     FOLLOWS THE RST INST.
ØØ6C C5                         PUSH BC        WITH THE TEXT (DE->)
ØØ6D 4E                         LOD  C,M       IF NOT =, ADD THE 2ND
ØØ6E Ø6ØØ                       LODI B,Ø       BYTE THAT FOLLOWS THE
ØØ7Ø Ø9                         ADD  HL,BC     RST TO THE OLD PC
ØØ71 C1                         POP  BC        I.E., DO A RELATIVE
ØØ72 1B                         DEC  DE        JUMP IF NOT =
ØØ73 13                  TC2    INC  DE        IF =, SKIP THOSE BYTES
ØØ74 23                         INC  HL        AND CONTINUE
ØØ75 E3                         XCH  HL,(SP)
ØØ76 C9                         RET  U
*
ØØ77 21ØØØØ              TSTNUM LODI HL,Ø      *** TSTNUM ***
ØØ7A 44                         LOD  B,H       TEST IF THE TEXT IS
ØØ7B EF                         IGNBLK         A NUMBER
ØØ7C FE3Ø                TN1    CMPI 'Ø'       IF NOT, RETURN Ø IN
ØØ7E D8                         RET  C         B AND HL
ØØ7F FE3A                       CMPI X'3A'     IF NUMBERS, CONVERT
ØØ81 DØ                         RET  NC        TO BINARY IN HL AND
ØØ82 3EFØ                       LODI A,X'FØ'   SET B TO # OF DIGITS
ØØ84 A4                         AND  H         IF H>255, THERE IS NO
ØØ85 C29FØØ                     JMP  NZ,QHOW   ROOM FOR NEXT DIGIT
```

```
ØØ88 Ø4                  INC  B         B COUNTS # OF DIGITS
ØØ89 C5                  PUSH BC
ØØ8A 444D                LOD  BC,HL     HL=1Ø*HL+(NEW DIGIT)
ØØ8C 29                  ADD  HL,HL     WHERE 1Ø* IS DONE BY
ØØ8D 29                  ADD  HL,HL     SHIFT AND ADD
ØØ8E Ø9                  ADD  HL,BC
ØØ8F 29                  ADD  HL,HL
ØØ9Ø 1A                  LD   A,(DE)    AND (DIGIT) IS FROM
ØØ91 13                  INC  DE        STRIPPING THE ASCII
ØØ92 E6ØF                ANDI X'ØF'     CODE
ØØ94 85                  ADD  L
ØØ95 6F                  LOD  L,A
ØØ96 3EØØ                LODI A,Ø
ØØ98 8C                  ADC  H
ØØ99 67                  LOD  H,A
ØØ9A C1                  POP  BC
ØØ9B 1A                  LD   A,(DE)    DO THIS DIGIT AFTER
ØØ9C F27CØØ              JMP  NS,TN1    DIGIT. S SAYS OVERFLOW
ØØ9F D5           QHOW   PUSH DE        *** ERROR: "HOW?" ***
ØØAØ 11A6ØØ       AHOW   LODI DE,HOW
ØØA3 C3A8Ø5              JMP  ERROR
ØØA6 484F573F     HOW    CHAR 'HOW?',@CR
ØØAA ØD
ØØAB 4F4B         OK     CHAR 'OK',@CR
ØØAD ØD
ØØAE 574841543F   WHAT   CHAR 'WHAT?',@CR
ØØB3 ØD
ØØB4 534F525259   SORRY  CHAR 'SORRY',@CR
ØØB9 ØD
*
**************************************************************
*
* *** MAIN ***
*
* THIS IS THE MAIN LOOP THAT COLLECTS THE TINY BASIC PROGRAM
* AND STORES IT IN THE MEMORY.
*
* AT START, IT PRINTS OUT "(CR)OK(CR)", AND INITIALIZES THE
* STACK AND SOME OTHER INTERNAL VARIABLES.  THEN IT PROMPTS
* ">" AND READS A LINE.  IF THE LINE STARTS WITH A NON-ZERO
* NUMBER, THIS NUMBER IS THE LINE NUMBER.  THE LINE NUMBER
* (IN 16 BIT BINARY) AND THE REST OF THE LINE (INCLUDING CR)
* IS STORED IN THE MEMORY.  IF A LINE WITH THE SAME LINE
* NUMBER IS ALREDY THERE, IT IS REPLACED BY THE NEW ONE.  IF
* THE REST OF THE LINE CONSISTS OF A CR ONLY, IT IS NOT STORED
* AND ANY EXISTING LINE WITH THE SAME LINE NUMBER IS DELETED.
*
* AFTER A LINE IS INSERTED, REPLACED, OR DELETED, THE PROGRAM
* LOOPS BACK AND ASK FOR ANOTHER LINE.  THIS LOOP WILL BE
* TERMINATED WHEN IT READS A LINE WITH ZERO OR NO LINE
* NUMBER; AND CONTROL IS TRANSFERED TO "DIRECT".
*
* TINY BASIC PROGRAM SAVE AREA STARTS AT THE MEMORY LOCATION
* LABELED "TXTBGN" AND ENDED AT "TXTEND".  WE ALWAYS FILL THIS
* AREA STARTING AT "TXTBGN", THE UNFILLED PORTION IS POINTED
* BY THE CONTENT OF A MEMORY LOCATION LABELED "TXTUNF".
*
* THE MEMORY LOCATION "CURRNT" POINTS TO THE LINE NUMBER
* THAT IS CURRENTLY BEING INTERPRETED.  WHILE WE ARE IN
* THIS LOOP OR WHILE WE ARE INTERPRETING A DIRECT COMMAND
```

```
* (SEE NEXT SECTION), "CURRNT" SHOULD POINT TO A Ø.
*
*                 START  LODI SP,STACK  THIS IS AT LOC. Ø
ØØBA CDØEØØ       ST1    CALL CRLF      AND JUMP TO HERE
ØØBD 11ABØØ              LODI DE,OK     DE->STRING
ØØCØ 97                  SUB  A         A=Ø
ØØC1 CD3CØ6              CALL PRTSTG    PRINT STRING UNTIL CR
ØØC4 21CBØØ              LODI HL,ST2+1  LITERAL Ø
ØØC7 22Ø1Ø8              ST   HL,CURRNT CURRNT->LINE # = Ø
ØØCA 21ØØØØ       ST2    LODI HL,Ø
ØØCD 22Ø7Ø8              ST   HL,LOPVAR
ØØDØ 22Ø3Ø8              ST   HL,STKGOS
ØØD3 3E3E         ST3    LODI A,'>'     PROMPT '>' AND
ØØD5 CDD6Ø5              CALL GETLN     READ A LINE
ØØD8 D5                  PUSH DE        DE->END OF LINE
ØØD9 11371F @@@@         LODI DE,BUFFER DE->BEGINNING OF LINE
ØØDC CD77ØØ              CALL TSTNUM    TEST IF IT IS A NUMBER
ØØDF EF                  IGNBLK
ØØEØ 7C                  LOD  A,H       HL=VALUE OF THE # OR
ØØE1 B5                  IOR  L         Ø IF NO # WAS FOUND
ØØE2 C1                  POP  BC        BC->END OF LINE
ØØE3 CAF5Ø1              JMP  Z,DIRECT
ØØE6 1B                  DEC  DE        BACKUP DE AND SAVE
ØØE7 7C                  LOD  A,H       VALUE OF LINE # THERE
ØØE8 12                  ST   A,(DE)
ØØE9 1B                  DEC  DE
ØØEA 7D                  LOD  A,L
ØØEB 12                  ST   A,(DE)
ØØEC C5D5                PUSH BC,DE     BC,DE->BEGIN, END
ØØEE 79                  LOD  A,C
ØØEF 93                  SUB  E
ØØFØ F5                  PUSH AF        A=# OF BYTES IN LINE
ØØF1 CD14Ø6              CALL FNDLN     FIND THIS LINE IN SAVE
ØØF4 D5                  PUSH DE        AREA, DE->SAVE AREA
ØØF5 C2Ø8Ø1              JMP  NZ,ST4    NZ:NOT FOUND, INSERT
ØØF8 D5                  PUSH DE        Z:FOUND, DELETE IT
ØØF9 CD3ØØ6              CALL FNDNXT    FIND NEXT LINE
*                                       DE->NEXT LINE
ØØFC C1                  POP  BC        BC->LINE TO BE DELETED
ØØFD 2A13Ø8              LD   HL,TXTUNF HL->UNFILLED SAVE AREA
Ø1ØØ CDBDØ6              CALL MVUP      MOVE UP TO DELETE
Ø1Ø3 6Ø69                LOD  HL,BC     TXTUNF->UNFILLED AREA
Ø1Ø5 2213Ø8              ST   HL,TXTUNF UPDATE
Ø1Ø8 C1           ST4    POP  BC        GET READY TO INSERT
Ø1Ø9 2A13Ø8              LD   HL,TXTUNF BUT FIRST CHECK IF
Ø1ØC F1                  POP  AF        THE LENGTH OF NEW LINE
Ø1ØD E5                  PUSH HL        IS 3 (LINE # AND CR)
Ø1ØE FEØ3                CMPI 3         THEN DO NOT INSERT
Ø11Ø CAØØØØ              JMP  Z,START   MUST CLEAR THE STACK
Ø113 85                  ADD  L         COMPUTE NEW TXTUNF
Ø114 6F                  LOD  L,A
Ø115 3EØØ                LODI A,Ø
Ø117 8C                  ADC  H
Ø118 67                  LOD  H,A       HL->NEW UNFILLED AREA
Ø119 11ØØ1F @@@@         LODI DE,TXTEND CHECK TO SEE IF THERE
Ø11C E7                  COMP           IS ENOUGH SPACE
Ø11D D2CFØ5              JMP  NC,QSORRY SORRY, NO ROOM FOR IT
Ø12Ø 2213Ø8              ST   HL,TXTUNF OK, UPDATE TXTUNF
Ø123 D1                  POP  DE        DE->OLD UNFILLED AREA
Ø124 CDC6Ø6              CALL MVDOWN
```

```
Ø127 D1E1                POP  DE,HL     DE->BEGIN, HL->END
Ø129 CDBDØ6              CALL MVUP      MOVE NEW LINE TO SAVE
Ø12C C3D3ØØ              JMP  ST3       AREA
*
***************************************************************
*
* *** TABLES *** DIRECT *** & EXEC ***
*
* THIS SECTION OF THE CODE TESTS A STRING AGAINST A TABLE.
* WHEN A MATCH IS FOUND, CONTROL IS TRANSFERED TO THE SECTION
* OF CODE ACCORDING TO THE TABLE.
*
* AT 'EXEC', DE SHOULD POINT TO THE STRING AND HL SHOULD POINT
* TO THE TABLE-1.  AT 'DIRECT', DE SHOULD POINT TO THE STRING,
* HL WILL BE SET UP TO POINT TO TAB1-1, WHICH IS THE TABLE OF
* ALL DIRECT AND STATEMENT COMMANDS.
*
* A '.' IN THE STRING WILL TERMINATE THE TEST AND THE PARTIAL
* MATCH WILL BE CONSIDERED AS A MATCH.  E.G., 'P.', 'PR.',
* 'PRI.', 'PRIN.', OR 'PRINT' WILL ALL MATCH 'PRINT'.
*
* THE TABLE CONSISTS OF ANY NUMBER OF ITEMS.  EACH ITEM
* IS A STRING OF CHARACTERS WITH BIT 7 SET TO Ø AND
* A JUMP ADDRESS STORED HI-LOW WITH BIT 7 OF THE HIGH
* BYTE SET TO 1.
*
* END OF TABLE IS AN ITEM WITH A JUMP ADDRESS ONLY.  IF THE
* STRING DOES NOT MATCH ANY OF THE OTHER ITEMS, IT WILL
* MATCH THIS NULL ITEM AS DEFAULT.
*
Ø12F              TAB1   EQU  *         DIRECT COMMANDS
Ø12F 4C495354            ITEM 'LIST',LIST
Ø133 8261
Ø135 52554E              ITEM 'RUN',RUN
Ø138 8233
Ø13A 4E4557              ITEM 'NEW',NEW
Ø13D 8226
Ø13F              TAB2   EQU  *         DIRECT/STATEMENT
Ø13F 4E455854            ITEM 'NEXT',NEXT
Ø143 8349
Ø145 4C4554              ITEM 'LET',LET
Ø148 84Ø7
Ø14A 4946                ITEM 'IF',IF
Ø14C 839A
Ø14E 474F544F            ITEM 'GOTO',GOTO
Ø152 8252
Ø154 474F535542          ITEM 'GOSUB',GOSUB
Ø159 82B1
Ø15B 52455455524E        ITEM 'RETURN',RETURN
Ø161 82D1
Ø163 52454D              ITEM 'REM',REM
Ø166 8396
Ø168 464F52              ITEM 'FOR',FOR
Ø16B 82EA
Ø16D 494E5Ø5554          ITEM 'INPUT',INPUT
Ø172 83B1
Ø174 5Ø52494E54          ITEM 'PRINT',PRINT
Ø179 8279
Ø17B 53544F5Ø            ITEM 'STOP',STOP
Ø17F 822F
```

```
Ø181 84Ø1                   ITEM ,DEFLT
Ø183 594F552Ø4D41592Ø       CHAR 'YOU MAY INSERT  MORE COMMANDS.'
Ø18B 494E534552542Ø2Ø
Ø193 4D4F52452Ø434F4D
Ø19B 4D414E44532E
Ø1A1                 TAB4   EQU  *            FUNCTIONS
Ø1A1 524E44                 ITEM 'RND',RND
Ø1A4 85Ø6
Ø1A6 414253                 ITEM 'ABS',ABS
Ø1A9 8531
Ø1AB 53495A45               ITEM 'SIZE',SIZE
Ø1AF 853D
Ø1B1 84EC                   ITEM ,XP4Ø
Ø1B3 594F552Ø4D41592Ø       CHAR 'YOU MAY INSERT  MORE FUNCTIONS'
Ø1BB 494E534552542Ø2Ø
Ø1C3 4D4F52452Ø46554E
Ø1CB 4354494F4E53
Ø1D1                 TAB5   EQU  *            "TO" IN "FOR"
Ø1D1 544F                   ITEM 'TO',FR1
Ø1D3 82FA
Ø1D5 85A4                   ITEM ,QWHAT
Ø1D7                 TAB6   EQU  *            "STEP" IN "FOR"
Ø1D7 5354455Ø               ITEM 'STEP',FR2
Ø1DB 83Ø4
Ø1DD 83Ø8                   ITEM ,FR3
Ø1DF                 TAB8   EQU  *            RELATION OPERATORS
Ø1DF 3E3D                   ITEM '>=',XP11
Ø1E1 8417
Ø1E3 23                     ITEM '#',XP12
Ø1E4 841D
Ø1E6 3E                     ITEM '>',XP13
Ø1E7 8423
Ø1E9 3D                     ITEM '=',XP15
Ø1EA 8432
Ø1EC 3C3D                   ITEM '<=',XP14
Ø1EE 842A
Ø1FØ 3C                     ITEM '<',XP16
Ø1F1 8438
Ø1F3 843E                   ITEM ,XP17
*
Ø1F5 212EØ1          DIRECT LODI HL,TAB1-1 *** DIRECT ***
*
Ø1F8                 EXEC   EQU  *            *** EXEC ***
Ø1F8 EF              EXØ    IGNBLK            IGNORE LEADING BLANKS
Ø1F9 D5                     PUSH DE           SAVE POINTER
Ø1FA 1A              EX1    LD   A,(DE)       IF FOUND '.' IN STRING
Ø1FB 13                     INC  DE           BEFORE ANY MISMATCH
Ø1FC FE2E                   CMPI '.'          WE DECLARE A MATCH
Ø1FE CA17Ø2                 JMP  Z,EX3
Ø2Ø1 23                     INC  HL           HL->TABLE
Ø2Ø2 BE                     CMP  M            IF MATCH, TEST NEXT
Ø2Ø3 CAFAØ1                 JMP  Z,EX1
Ø2Ø6 3E7F                   LODI A,X'7F'      ELSE, SEE IF BIT 7
Ø2Ø8 1B                     DEC  DE           OF TABLE IS SET, WHICH
Ø2Ø9 BE                     CMP  M            IS THE JUMP ADDR. (HI)
Ø2ØA DA1EØ2                 JMP  C,EX5        C:YES, MATCHED
Ø2ØD 23              EX2    INC  HL           NC:NO, FIND JUMP ADDR.
Ø2ØE BE                     CMP  M
Ø2ØF D2ØDØ2                 JMP  NC,EX2
Ø212 23                     INC  HL           PT'R TO NEXT TAB. ITEM
```

```
Ø213 D1                    POP  DE          RESTORE STRING POINTER
Ø214 C3F8Ø1                JMP  EXØ         TEST AGAINST NEXT ITEM
Ø217 3E7F         EX3      LODI A,X'7F'     PARTIAL MATCH, FIND
Ø219 23           EX4      INC  HL          JUMP ADDR., WHICH IS
Ø21A BE                    CMP  M           FLAGGED BY BIT 7
Ø21B D219Ø2                JMP  NC,EX4
Ø21E 7E           EX5      LOD  A,M         LOAD HL WITH THE JUMP
Ø21F 23                    INC  HL          ADDRESS FROM THE TABLE
Ø22Ø 6E                    LOD  L,M
Ø221 E67F                  ANDI X'7F'       MASK OFF BIT 7
Ø223 67                    LOD  H,A
Ø224 F1                    POP  AF          CLEAN UP THE GABAGE
Ø225 E9                    JMP  (HL)        AND WE GO DO IT
*
**************************************************************
*
* WHAT FOLLOWS IS THE CODE TO EXECUTE DIRECT AND STATEMENT
* COMMANDS.  CONTROL IS TRANSFERED TO THESE POINTS VIA THE
* COMMAND TABLE LOOKUP CODE OF 'DIRECT' AND 'EXEC' IN LAST
* SECTION.  AFTER THE COMMAND IS EXECUTED, CONTROL IS
* TRANSFERED TO OTHER SECTIONS AS FOLLOWS:
*
* FOR 'LIST', 'NEW', AND 'STOP': GO BACK TO 'START'
* FOR 'RUN': GO EXECUTE THE FIRST STORED LINE IF ANY; ELSE
* GO BACK TO 'START'.
* FOR 'GOTO' AND 'GOSUB': GO EXECUTE THE TARGET LINE.
* FOR 'RETURN' AND 'NEXT': GO BACK TO SAVED RETURN LINE.
* FOR ALL OTHERS: IF 'CURRNT' -> Ø, GO TO 'START', ELSE
* GO EXECUTE NEXT COMMAND.  (THIS IS DONE IN 'FINISH'.)
*
**************************************************************
*
* *** NEW *** STOP *** RUN (& FRIENDS) *** & GOTO ***
*
* 'NEW(CR)' SETS 'TXTUNF' TO POINT TO 'TXTBGN'
*
* 'STOP(CR)' GOES BACK TO 'START'
*
* 'RUN(CR)' FINDS THE FIRST STORED LINE, STORE ITS ADDRESS (IN
* 'CURRNT'), AND START EXECUTE IT.  NOTE THAT ONLY THOSE
* COMMANDS IN TAB2 ARE LEGAL FOR STORED PROGRAM.
*
* THERE ARE 3 MORE ENTRIES IN 'RUN':
* 'RUNNXL' FINDS NEXT LINE, STORES ITS ADDR. AND EXECUTES IT.
* 'RUNTSL' STORES THE ADDRESS OF THIS LINE AND EXECUTES IT.
* 'RUNSML' CONTINUES THE EXECUTION ON SAME LINE.
*
* 'GOTO EXPR(CR)' EVALUATES THE EXPRESSION, FIND THE TARGET
* LINE, AND JUMP TO 'RUNTSL' TO DO IT.
*
Ø226 CDAØØ5       NEW      CALL ENDCHK      *** NEW(CR) ***
Ø229 2115Ø3                LODI HL,TXTBGN
Ø22C 2213Ø8                ST   HL,TXTUNF
*
Ø22F CDAØØ5       STOP     CALL ENDCHK      *** STOP(CR) ***
Ø232 C7                    RSTART
*
Ø233 CDAØØ5       RUN      CALL ENDCHK      *** RUN(CR) ***
Ø236 1115Ø3                LODI DE,TXTBGN FIRST SAVED LINE
*
```

```
Ø239 21ØØØØ         RUNNXL LODI HL,Ø        *** RUNNXL ***
Ø23C CD1CØ6                CALL FNDLNP     FIND WHATEVER LINE #
Ø23F DAØØØØ                JMP  C,START    C:PASSED TXTUNF, QUIT
*
Ø242 EB             RUNTSL XCH  HL,DE       *** RUNTSL ***
Ø243 22Ø1Ø8                ST   HL,CURRNT  SET 'CURRNT'->LINE #
Ø246 EB                    XCH  HL,DE
Ø247 1313                  INC  DE,2       BUMP PASS LINE #
*
Ø249 CD32Ø7         RUNSML CALL CHKIO       *** RUNSML ***
Ø24C 213EØ1                LODI HL,TAB2-1  FIND COMMAND IN TAB2
Ø24F C3F8Ø1                JMP       EXEC  AND EXECUTE IT
*
Ø252 DF             GOTO   EXPR            *** GOTO EXPR ***
Ø253 D5                    PUSH DE         SAVE FOR ERROR ROUTINE
Ø254 CDAØØ5                CALL ENDCHK     MUST FIND A CR
Ø257 CD14Ø6                CALL FNDLN      FIND THE TARGET LINE
Ø25A C2AØØØ                JMP  NZ,AHOW    NO SUCH LINE #
Ø25D F1                    POP  AF         CLEAR THE "PUSH DE"
Ø25E C342Ø2                JMP  RUNTSL     GO DO IT
*
**************************************************************
*
* *** LIST *** & PRINT ***
*
* LIST HAS TWO FORMS:
* 'LIST(CR)' LISTS ALL SAVED LINES
* 'LIST #(CR)' START LIST AT THIS LINE #
* YOU CAN STOP THE LISTING BY CONTROL C KEY
*
* PRINT COMMAND IS 'PRINT ....;' OR 'PRINT ....(CR)'
* WHERE '....' IS A LIST OF EXPRESIONS, FORMATS, BACK-
* ARROWS, AND STRINGS.  THESE ITEMS ARE SEPERATED BY COMMAS.
*
* A FORMAT IS A POUND SIGN FOLLOWED BY A NUMBER.  IT CONTROLS
* THE NUMBER OF SPACES THE VALUE OF A EXPRESION IS GOING TO
* BE PRINTED.  IT STAYS EFFECTIVE FOR THE REST OF THE PRINT
* COMMAND UNLESS CHANGED BY ANOTHER FORMAT.  IF NO FORMAT IS
* SPECIFIED, 6 POSITIONS WILL BE USED.
*
* A STRING IS QUOTED IN A PAIR OF SINGLE QUOTES OR A PAIR OF
* DOUBLE QUOTES.
*
* A BACK-ARROW MEANS GENERATE A (CR) WITHOUT (LF)
*
* A (CRLF) IS GENERATED AFTER THE ENTIRE LIST HAS BEEN
* PRINTED OR IF THE LIST IS A NULL LIST.  HOWEVER IF THE LIST
* ENDED WITH A COMMA, NO (CRLF) IS GENERATED.
*
Ø261 CD77ØØ         LIST   CALL TSTNUM     TEST IF THERE IS A #
Ø264 CDAØØ5                CALL ENDCHK     IF NO # WE GET A Ø
Ø267 CD14Ø6                CALL FNDLN      FIND THIS OR NEXT LINE
Ø26A DAØØØØ         LS1    JMP  C,START    C:PASSED TXTUNF
Ø26D CDAAØ6                CALL PRTLN      PRINT THE LINE
Ø27Ø CD32Ø7                CALL CHKIO      STOP IF HIT CONTROL-C
Ø273 CD1CØ6                CALL FNDLNP     FIND NEXT LINE
Ø276 C36AØ2                JMP  LS1        AND LOOP BACK
*
Ø279 ØEØ6           PRINT  LODI C,6        C = # OF SPACES
Ø27B CF                    TSTC ';',PR2    IF NULL LIST & ";"
```

```
Ø27C 3B
Ø27D Ø6
Ø27E CDØEØØ                  CALL CRLF      GIVE CR-LF AND
Ø281 C349Ø2                  JMP  RUNSML    CONTINUE SAME LINE
Ø284 CF             PR2      TSTC @CR,PRØ   IF NULL LIST (CR)
Ø285 ØD
Ø286 Ø6
Ø287 CDØEØØ                  CALL CRLF      ALSO GIVE CR-LF AND
Ø28A C339Ø2                  JMP  RUNNXL    GO TO NEXT LINE
Ø28D CF             PRØ      TSTC '#',PR1   ELSE IS IT FORMAT?
Ø28E 23
Ø28F Ø5
Ø29Ø DF                      EXPR           YES, EVALUATE EXPR.
Ø291 4D                      LOD  C,L       AND SAVE IT IN C
Ø292 C39BØ2                  JMP  PR3       LOOK FOR MORE TO PRINT
Ø295 CD48Ø6         PR1      CALL QTSTG     OR IS IT A STRING?
Ø298 C3A8Ø2                  JMP  PR8       IF NOT, MUST BE EXPR.
Ø29B CF             PR3      TSTC ',',PR6   IF ",", GO FIND NEXT
Ø29C 2C
Ø29D Ø6
Ø29E CD91Ø5                  CALL FIN       IN THE LIST.
Ø2A1 C38DØ2                  JMP  PRØ       LIST CONTINUES
Ø2A4 CDØEØØ         PR6      CALL CRLF      LIST ENDS
Ø2A7 F7                      FINISH
Ø2A8 DF             PR8      EXPR           EVALUATE THE EXPR
Ø2A9 C5                      PUSH BC
Ø2AA CD6EØ6                  CALL PRTNUM    PRINT THE VALUE
Ø2AD C1                      POP  BC
Ø2AE C39BØ2                  JMP  PR3       MORE TO PRINT?
*
**************************************************************
*
* *** GOSUB *** & RETURN ***
*
* 'GOSUB EXPR;' OR 'GOSUB EXPR (CR)' IS LIKE THE 'GOTO'
* COMMAND, EXCEPT THAT THE CURRENT TEXT POINTER, STACK POINTER
* ETC. ARE SAVE SO THAT EXECUTION CAN BE CONTINUED AFTER THE
* SUBROUTINE 'RETURN'.  IN ORDER THAT 'GOSUB' CAN BE NESTED
* (AND EVEN RECURSIVE), THE SAVE AREA MUST BE STACKED.
* THE STACK POINTER IS SAVED IN 'STKGOS'. THE OLD 'STKGOS' IS
* SAVED IN THE STACK.  IF WE ARE IN THE MAIN ROUTINE, 'STKGOS'
* IS ZERO (THIS WAS DONE BY THE "MAIN" SECTION OF THE CODE),
* BUT WE STILL SAVE IT AS A FLAG FOR NO FURTHER 'RETURN'S.
*
* 'RETURN(CR)' UNDOS EVERYTHING THAT 'GOSUB' DID, AND THUS
* RETURN THE EXCUTION TO THE COMMAND AFTER THE MOST RECENT
* 'GOSUB'.  IF 'STKGOS' IS ZERO, IT INDICATES THAT WE
* NEVER HAD A 'GOSUB' AND IS THUS AN ERROR.
*
Ø2B1 CDF1Ø6         GOSUB    CALL PUSHA     SAVE THE CURRENT "FOR"
Ø2B4 DF                      EXPR           PARAMETERS
Ø2B5 D5                      PUSH DE        AND TEXT POINTER
Ø2B6 CD14Ø6                  CALL FNDLN     FIND THE TARGET LINE
Ø2B9 C2AØØØ                  JMP  NZ,AHOW   NOT THERE. SAY "HOW?"
Ø2BC 2AØ1Ø8                  LD   HL,CURRNT FOUND IT, SAVE OLD
Ø2BF E5                      PUSH HL        'CURRNT' OLD 'STKGOS'
Ø2CØ 2AØ3Ø8                  LD   HL,STKGOS
Ø2C3 E5                      PUSH HL
Ø2C4 21ØØØØ                  LODI HL,Ø      AND LOAD NEW ONES
Ø2C7 22Ø7Ø8                  ST   HL,LOPVAR
```

```
Ø2CA 39                     ADD  HL,SP
Ø2CB 22Ø3Ø8                 ST   HL,STKGOS
Ø2CE C342Ø2                 JMP  RUNTSL     THEN RUN THAT LINE
Ø2D1 CDAØØ5          RETURN CALL ENDCHK     THERE MUST BE A CR
Ø2D4 2AØ3Ø8                 LD   HL,STKGOS OLD STACK POINTER
Ø2D7 7C                     LOD  A,H        Ø MEANS NOT EXIST
Ø2D8 B5                     IOR  L
Ø2D9 CAA4Ø5                 JMP  Z,QWHAT    SO, WE SAY: "WHAT?"
Ø2DC F9                     LOD  SP,HL      ELSE, RESTORE IT
Ø2DD E1                     POP  HL
Ø2DE 22Ø3Ø8                 ST   HL,STKGOS AND THE OLD 'STKGOS'
Ø2E1 E1                     POP  HL
Ø2E2 22Ø1Ø8                 ST   HL,CURRNT AND THE OLD 'CURRNT'
Ø2E5 D1                     POP  DE         OLD TEXT POINTER
Ø2E6 CDD5Ø6                 CALL POPA       OLD "FOR" PARAMETERS
Ø2E9 F7                     FINISH          AND WE ARE BACK HOME
*
*******************************************************************
*
* *** FOR *** & NEXT ***
*
* 'FOR' HAS TWO FORMS:
* 'FOR VAR=EXP1 TO EXP2 STEP EXP1' AND 'FOR VAR=EXP1 TO EXP2'
* THE SECOND FORM MEANS THE SAME THING AS THE FIRST FORM WITH
* EXP1=1.  (I.E., WITH A STEP OF +1.)
* TBI WILL FIND THE VARIABLE VAR. AND SET ITS VALUE TO THE
* CURRENT VALUE OF EXP1.  IT ALSO EVALUATES EXPR2 AND EXP1
* AND SAVE ALL THESE TOGETHER WITH THE TEXT POINTER ETC. IN
* THE 'FOR' SAVE AREA, WHICH CONSISTS OF 'LOPVAR', 'LOPINC',
* 'LOPLMT', 'LOPLN', AND 'LOPPT'.  IF THERE IS ALREADY SOME-
* THING IN THE SAVE AREA (THIS IS INDICATED BY A NON-ZERO
* 'LOPVAR'), THEN THE OLD SAVE AREA IS SAVED IN THE STACK
* BEFORE THE NEW ONE OVERWRITES IT.
* TBI WILL THEN DIG IN THE STACK AND FIND OUT IF THIS SAME
* VARIABLE WAS USED IN ANOTHER CURRENTLY ACTIVE 'FOR' LOOP.
* IF THAT IS THE CASE, THEN THE OLD 'FOR' LOOP IS DEACTIVATED.
* (PURGED FROM THE STACK..)
*
* 'NEXT VAR' SERVES AS THE LOGICAL (NOT NECESSARILLY PHYSICAL)
* END OF THE 'FOR' LOOP.  THE CONTROL VARIABLE VAR. IS CHECKED
* WITH THE 'LOPVAR'.  IF THEY ARE NOT THE SAME, TBI DIGS IN
* THE STACK TO FIND THE RIGHT ONE AND PURGES ALL THOSE THAT
* DID NOT MATCH.  EITHER WAY, TBI THEN ADDS THE 'STEP' TO
* THAT VARIABLE AND CHECK THE RESULT WITH THE LIMIT.  IF IT
* IS WITHIN THE LIMIT, CONTROL LOOPS BACK TO THE COMMAND
* FOLLOWING THE 'FOR'.  IF OUTSIDE THE LIMIT, THE SAVE ARER
* IS PURGED AND EXECUTION CONTINUES.
*
Ø2EA CDF1Ø6          FOR    CALL PUSHA      SAVE THE OLD SAVE AREA
Ø2ED CD7EØ5                 CALL SETVAL     SET THE CONTROL VAR.
Ø2FØ 2B                     DEC  HL         HL IS ITS ADDRESS
Ø2F1 22Ø7Ø8                 ST   HL,LOPVAR SAVE THAT
Ø2F4 21DØØ1                 LODI HL,TAB5-1 USE 'EXEC' TO LOOK
Ø2F7 C3F8Ø1                 JMP  EXEC       FOR THE WORD 'TO'
Ø2FA DF              FR1    EXPR            EVALUATE THE LIMIT
Ø2FB 22ØBØ8                 ST   HL,LOPLMT SAVE THAT
Ø2FE 21D6Ø1                 LODI HL,TAB6-1 USE 'EXEC' TO LOOK
Ø3Ø1 C3F8Ø1                 JMP  EXEC       FOR THE WORD 'STEP'
Ø3Ø4 DF              FR2    EXPR            FOUND IT, GET STEP
Ø3Ø5 C3ØBØ3                 JMP  FR4
```

```
 Ø3Ø8 21Ø1ØØ       FR3    LODI HL,1      NOT FOUND, SET TO 1
 Ø3ØB 22Ø9Ø8       FR4    ST   HL,LOPINC SAVE THAT TOO
 Ø3ØE 2AØ1Ø8       FR5    LD   HL,CURRNT SAVE CURRENT LINE #
 Ø311 22ØDØ8              ST   HL,LOPLN
 Ø314 EB                  XCH  HL,DE     AND TEXT POINTER
 Ø315 22ØFØ8              ST   HL,LOPPT
 Ø318 Ø1ØAØØ              LODI BC,1Ø     DIG INTO STACK TO
 Ø31B 2AØ7Ø8              LD   HL,LOPVAR FIND 'LOPVAR'
 Ø31E EB                  XCH  HL,DE
 Ø31F 6Ø                  LOD  H,B
 Ø32Ø 68                  LOD  L,B       HL=Ø NOW
 Ø321 39                  ADD  HL,SP     HERE IS THE STACK
 Ø322 3E                  SKIP
 Ø323 Ø9           FR7    ADD  HL,BC     EACH LEVEL IS 1Ø DEEP
 Ø324 7E                  LOD  A,M       GET THAT OLD 'LOPVAR'
 Ø325 23                  INC  HL
+Ø326 B6                  IOR  M
 Ø327 CA44Ø3              JMP  Z,FR8     Ø SAYS NO MORE IN IT
 Ø32A 7E                  LOD  A,M
 Ø32B 2B                  DEC  HL
 Ø32C BA                  CMP  D         SAME AS THIS ONE?
 Ø32D C223Ø3              JMP  NZ,FR7
 Ø33Ø 7E                  LOD  A,M       THE OTHER HALF?
 Ø331 BB                  CMP  E
 Ø332 C223Ø3              JMP  NZ,FR7
 Ø335 EB                  XCH  HL,DE     YES, FOUND ONE
 Ø336 21ØØØØ              LODI HL,Ø
 Ø339 39                  ADD  HL,SP     TRY TO MOVE SP
 Ø33A 444D                LOD  BC,HL
 Ø33C 21ØAØØ              LODI HL,1Ø
 Ø33F 19                  ADD  HL,DE
 Ø34Ø CDC6Ø6              CALL MVDOWN    AND PURGE 1Ø WORDS
 Ø343 F9                  LOD  SP,HL     IN THE STACK
 Ø344 2AØFØ8       PR8    LD   HL,LOPPT  JOE DONE, RESTORE DE
 Ø347 EB                  XCH  HL,DE
 Ø348 F7                  FINISH         AND CONTINUE
 *
 Ø349 FF           NEXT   TSTV           GET ADDRESS OF VAR.
 Ø34A DAA4Ø5              JMP  C,QWHAT   NO VARIABLE, "WHAT?"
 Ø34D 22Ø5Ø8              ST   HL,VARNXT YES, SAVE IT
 Ø35Ø D5           NXØ    PUSH DE        SAVE TEXT POINTER
 Ø351 EB                  XCH  HL,DE
 Ø352 2AØ7Ø8              LD   HL,LOPVAR GET VAR. IN 'FOR'
 Ø355 7C                  LOD  A,H
 Ø356 B5                  IOR  L         Ø SAYS NEVER HAD ONE
 Ø357 CAA5Ø5              JMP  Z,AWHAT   SO WE ASK: "WHAT?"
 Ø35A E7                  COMP           ELSE WE CHECK THEM
 Ø35B CA68Ø3              JMP  Z,NX3     OK, THEY AGREE
 Ø35E D1                  POP  DE        NO, LET'S SEE
 Ø35F CDD5Ø6              CALL POPA      PURGE CURRENT LOOP
 Ø362 2AØ5Ø8              LD   HL,VARNXT AND POP ONE LEVEL
 Ø365 C35ØØ3              JMP  NXØ       GO CHECK AGAIN
 Ø368 5E           NX3    LOD  E,M       COME HERE WHEN AGREED
 Ø369 23                  INC  HL
 Ø36A 56                  LOD  D,M       DE=VALUE OF VAR.
 Ø36B 2AØ9Ø8              LD   HL,LOPINC
 Ø36E E5                  PUSH HL
 Ø36F 19                  ADD  HL,DE     ADD ONE STEP
 Ø37Ø EB                  XCH  HL,DE
 Ø371 2AØ7Ø8              LD   HL,LOPVAR PUT IT BACK
```

```
Ø374 73                  LOD  M,E
Ø375 23                  INC  HL
Ø376 72                  LOD  M,D
Ø377 2AØBØ8              LD   HL,LOPLMT HL->LIMIT
Ø37A F1                  POP  AF        OLD HL
Ø37B B7                  IOR  A
Ø37C F28ØØ3              JMP  NS,NX1    STEP > Ø
Ø37F EB                  XCH  HL,DE     STEP < Ø
Ø38Ø CD76Ø5       NX1    CALL CKHLDE    COMPARE WITH LIMIT
Ø383 D1                  POP  DE        RESTORE TEXT POINTER
Ø384 DA92Ø3              JMP  C,NX2     OUTSIDE LIMIT
*Ø387 2AØDØ8)            LD   HL,LOPLN  WITHIN LIMIT, GO
Ø38A 22Ø1Ø8              ST   HL,CURRNT BACK TO THE SAVED
Ø38D 2AØFØ8              LD   HL,LOPPT  'CURRNT' AND TEXT
Ø39Ø EB                  XCH  HL,DE     POINTER
Ø391 F7                  FINISH
Ø392 CDD5Ø6       NX2    CALL POPA      PURGE THIS LOOP
Ø395 F7                  FINISH
*
**************************************************************
*
* *** REM *** IF *** INPUT *** & LET (& DEFLT) ***
*
* 'REM' CAN BE FOLLOWED BY ANYTHING AND IS IGNORED BY TBI.
* TBI TREATS IT LIKE AN 'IF' WITH A FALSE CONDITION.
*
* 'IF' IS FOLLOWED BY AN EXPR. AS A CONDITION AND ONE OR MORE
* COMMANDS (INCLUDING OUTHER 'IF'S) SEPERATED BY SEMI-COLONS.
* NOTE THAT THE WORD 'THEN' IS NOT USED.  TBI EVALUATES THE
* EXPR. IF IT IS NON-ZERO, EXECUTION CONTINUES.  IF THE
* EXPR. IS ZERO, THE COMMANDS THAT FOLLOWS ARE IGNORED AND
* EXECUTION CONTINUES AT THE NEXT LINE.
*
* 'INPUT' COMMAND IS LIKE THE 'PRINT' COMMAND, AND IS FOLLOWED
* BY A LIST OF ITEMS.  IF THE ITEM IS A STRING IN SINGLE OR
* DOUBLE QUOTES, OR IS A BACK-ARROW, IT HAS THE SAME EFFECT AS
* IN 'PRINT'.  IF AN ITEM IS A VARIABLE, THIS VARIABLE NAME IS
* PRINTED OUT FOLLOWED BY A COLON.  THEN TBI WAITS FOR AN
* EXPR. TO BE TYPED IN.  THE VARIABLE IS THEN SET TO THE
* VALUE OF THIS EXPR.  IF THE VARIABLE IS PROCEDED BY A STRING
* (AGAIN IN SINGLE OR DOUBLE QUOTES), THE STRING WILL BE
* PRINTED FOLLOWED BY A COLON.  TBI THEN WAITS FOR INPUT EXPR.
* AND SET THE VARIABLE TO THE VALUE OF THE EXPR.
*
* IF THE INPUT EXPR. IS INVALID, TBI WILL PRINT "WHAT?",
* "HOW?" OR "SORRY" AND REPRINT THE PROMPT AND REDO THE INPUT.
* THE EXECUTION WILL NOT TERMINATE UNLESS YOU TYPE CONTROL-C.
* THIS IS HANDLED IN 'INPERR'.
*
* 'LET' IS FOLLOWED BY A LIST OF ITEMS SEPERATED BY COMMAS.
* EACH ITEM CONSISTS OF A VARIABLE, AN EQUAL SIGN, AND AN EXPR.
* TBI EVALUATES THE EXPR. AND SET THE VARIBLE TO THAT VALUE.
* TBI WILL ALSO HANDLE 'LET' COMMAND WITHOUT THE WORD 'LET'.
* THIS IS DONE BY 'DEFLT'.
*
Ø396 21ØØØØ       REM    LODI HL,Ø      *** REM ***
Ø399 3E                  SKIP           THIS IS LIKE 'IF Ø'
*
Ø39A DF           IF     EXPR           *** IF ***
Ø39B 7C                  LOD  A,H       IS THE EXPR.=Ø?
```

```
Ø39C B5                   IOR  L
Ø39D C249Ø2               JMP  NZ,RUNSML NO, CONTINUE
Ø3AØ CD32Ø6               CALL FNDSKP    YES, SKIP REST OF LINE
Ø3A3 D242Ø2               JMP  NC,RUNTSL AND RUN THE NEXT LINE
Ø3A6 C7                   RSTART         IF NO NEXT, RE-START
*
Ø3A7 2AØ5Ø8        INPERR LD   HL,STKINP *** INPERR ***
Ø3AA F9                   LOD  SP,HL     RESTORE OLD SP
Ø3AB E1                   POP  HL        AND OLD 'CURRNT'
Ø3AC 22Ø1Ø8               ST   HL,CURRNT
Ø3AF D1                   POP  DE        AND OLD TEXT POINTER
Ø3BØ D1                   POP  DE        REDO INPUT
*
Ø3B1               INPUT  EQU  *         *** INPUT ***
Ø3B1 D5            IP1    PUSH DE        SAVE IN CASE OF ERROR
Ø3B2 CD48Ø6               CALL QTSTG     IS NEXT ITEM A STRING?
Ø3B5 C3BFØ3               JMP  IP2       NO
Ø3B8 FF                   TSTV           YES. BUT FOLLOWED BY A
Ø3B9 DAF9Ø3               JMP  C,IP4     VARIABLE?   NO.
Ø3BC C3CFØ3               JMP  IP3       YES.  INPUT VARIABLE
Ø3BF D5            IP2    PUSH DE        SAVE FOR 'PRTSTG'
Ø3CØ FF                   TSTV           MUST BE VARIABLE NOW
Ø3C1 DAA4Ø5               JMP  C,QWHAT   "WHAT?" IT IS NOT?
Ø3C4 1A                   LD   A,(DE)    GET READY FOR 'PRTSTG'
Ø3C5 4F                   LOD  C,A
Ø3C6 97                   SUB  A
Ø3C7 12                   ST   A,(DE)
Ø3C8 D1                   POP  DE
Ø3C9 CD3CØ6               CALL PRTSTG    PRINT STRING AS PROMPT
Ø3CC 79                   LOD  A,C       RESTORE TEXT
Ø3CD 1B                   DEC  DE
Ø3CE 12                   ST   A,(DE)
Ø3CF D5            IP3    PUSH DE        SAVE IN CASE OF ERROR
Ø3DØ EB                   XCH  HL,DE
Ø3D1 2AØ1Ø8               LD   HL,CURRNT ALSO SAVE 'CURRNT'
Ø3D4 E5                   PUSH HL
Ø3D5 21B1Ø3               LODI HL,IP1    A NEGATIVE NUMBER
Ø3D8 22Ø1Ø8               ST   HL,CURRNT AS A FLAG
Ø3DB 21ØØØØ               LODI HL,Ø      SAVE SP TOO
Ø3DE 39                   ADD  HL,SP
Ø3DF 22Ø5Ø8               ST   HL,STKINP
Ø3E2 D5                   PUSH DE        OLD HL
Ø3E3 3E3A                 LODI A,':'     PRINT THIS TOO
Ø3E5 CDD6Ø5               CALL GETLN     AND GET A LINE
Ø3E8 11371F @@@@          LODI DE,BUFFER POINTS TO BUFFER
Ø3EB DF                   EXPR           EVALUATE INPUT
Ø3EC ØØØØØØ               NOP  3         CAN BE 'CALL ENDCHK'
Ø3EF D1                   POP  DE        OK, GET OLD HL
Ø3FØ EB                   XCH  HL,DE
Ø3F1 73                   LOD  M,E       SAVE VALUE IN VAR.
Ø3F2 23                   INC  HL
Ø3F3 72                   LOD  M,D
Ø3F4 E1                   POP  HL        GET OLD 'CURRNT'
Ø3F5 22Ø1Ø8               ST   HL,CURRNT
Ø3F8 D1                   POP  DE        AND OLD TEXT POINTER
Ø3F9 F1            IP4    POP  AF        PURGE JUNK IN STACK
Ø3FA CF                   TSTC ',',IP5   IS NEXT CH. ','?
Ø3FB 2C
Ø3FC Ø3
Ø3FD C3B1Ø3               JMP  IP1       YES, MORE ITEMS.
```

```
Ø4ØØ F7           IP5   FINISH
*
Ø4Ø1 1A           DEFLT LD   A,(DE)     *** DEFLT ***
Ø4Ø2 FEØD               CMPI @CR        EMPTY LINE IS OK
Ø4Ø4 CA1ØØ4             JMP  Z,LT1      ELSE IT IS 'LET'
*
Ø4Ø7 CD7EØ5       LET   CALL SETVAL     *** LET ***
Ø4ØA CF                 TSTC ',',LT1    SET VALUE TO VAR.
Ø4ØB 2C
Ø4ØC Ø3
Ø4ØD C3Ø7Ø4             JMP  LET        ITEM BY ITEM
Ø41Ø F7           LT1   FINISH          UNTIL FINISH
*
**************************************************************
*
* *** EXPR ***
*
* 'EXPR' EVALUATES ARITHMETICAL OR LOGICAL EXPRESSIONS.
* <EXPR>::=<EXPR2>
*          <EXPR2><REL.OP.><EXPR2>
* WHERE <REL.OP.> IS ONE OF THE OPERATORS IN TAB8 AND THE
* RESULT OF THESE OPERATIONS IS 1 IF TRUE AND Ø IF FALSE.
* <EXPR2>::=(+ OR -)<EXPR3>(+ OR -<EXPR3>)(....)
* WHERE () ARE OPTIONAL AND (....) ARE OPTIONAL REPEATS.
* <EXPR3>::=<EXPR4>(<* OR /><EXPR4>)(....)
* <EXPR4>::=<VARIABLE>
*           <FUNCTION>
*           (<EXPR>)
* <EXPR> IS RECURSIVE SO THAT VARIABLE '@' CAN HAVE AN <EXPR>
* AS INDEX, FUNCTIONS CAN HAVE AN <EXPR> AS ARGUMENTS, AND
* <EXPR4> CAN BE AN <EXPR> IN PARANTHESE.
*
*                 EXPR  CALL EXPR2      THIS IS AT LOC. 18
*                       PUSH HL         SAVE <EXPR2> VALUE
Ø411 21DEØ1       EXPR1 LODI HL,TAB8-1 LOOKUP REL.OP.
Ø414 C3F8Ø1             JMP  EXEC       GO DO IT
Ø417 CD4ØØ4       XP11  CALL XP18       REL.OP.">="
Ø41A D8                 RET  C          NO, RETURN HL=Ø
Ø41B 6F                 LOD  L,A        YES, RETURN HL=1
Ø41C C9                 RET  U
Ø41D CD4ØØ4       XP12  CALL XP18       REL.OP."#"
Ø42Ø C8                 RET  Z          FALSE, RETURN HL=Ø
Ø421 6F                 LOD  L,A        TRUE, RETURN HL=1
Ø422 C9                 RET  U
Ø423 CD4ØØ4       XP13  CALL XP18       REL.OP.">"
Ø426 C8                 RET  Z          FALSE
Ø427 D8                 RET  C          ALSO FALSE, HL=Ø
Ø428 6F                 LOD  L,A        TRUE, HL=1
Ø429 C9                 RET  U
Ø42A CD4ØØ4       XP14  CALL XP18       REL.OP."<="
Ø42D 6F                 LOD  L,A        SET HL=1
Ø42E C8                 RET  Z          REL. TRUE, RETURN
Ø42F D8                 RET  C
Ø43Ø 6C                 LOD  L,H        ELSE SET HL=Ø
Ø431 C9                 RET  U
Ø432 CD4ØØ4       XP15  CALL XP18       REL.OP."="
Ø435 CØ                 RET  NZ         FALSE, RETRUN HL=Ø
Ø436 6F                 LOD  L,A        ELSE SET HL=1
Ø437 C9                 RET  U
Ø438 CD4ØØ4       XP16  CALL XP18       REL.OP."<"
```

```
Ø43B DØ                RET  NC         PALSE, RETURN HL=Ø
Ø43C 6F                LOD  L,A        ELSE SET HL=1
Ø43D C9                RET  U
Ø43E E1         XP17   POP  HL         NOT REL.OP.
Ø43F C9                RET  U          RETURN HL=<EXPR2>
Ø44Ø 79         XP18   LOD  A,C        SUBROUTINE FOR ALL
Ø441 E1C1              POP  HL,BC      REL.OP.'S
Ø443 E5C5              PUSH HL,BC      REVERSE TOP OF STACK
Ø445 4F                LOD  C,A
Ø446 CD55Ø4            CALL EXPR2      GET 2ND <EXPR2>
Ø449 EB                XCH  HL,DE      VALUE IN DE NOW
Ø44A E3                XCH  HL,(SP)    1ST <EXPR2> IN HL
Ø44B CD76Ø5            CALL CKHLDE     COMPARE 1ST WITH 2ND
Ø44E D1                POP  DE         RESTORE TEXT POINTER
Ø44F 21ØØØØ            LODI HL,Ø       SET HL=Ø, A=1
Ø452 3EØ1              LODI A,1
Ø454 C9                RET  U
*
Ø455 CF         EXPR2  TSTC '-',XP21   NAGATIVE SIGN?
Ø456 2D
Ø457 Ø6
Ø458 21ØØØØ            LODI HL,Ø       YES, FAKE 'Ø-'
Ø45B C37FØ4            JMP  XP26       TREAT LIKE SUBTRACT
Ø45E CF         XP21   TSTC '+',XP22   POSITIVE SIGN? IGNORE
Ø45F 2B
Ø46Ø ØØ
Ø461 CD89Ø4     XP22   CALL EXPR3      1ST <EXPR3>
Ø464 CF         XP23   TSTC '+',XP25   ADD?
Ø465 2B
Ø466 15
Ø467 E5                PUSH HL         YES, SAVE VALUE
Ø468 CD89Ø4            CALL EXPR3      GET 2ND <EXPR3>
Ø46B EB         XP24   XCH  HL,DE      2ND IN DE
Ø46C E3                XCH  HL,(SP)    1ST IN HL
Ø46D 7C                LOD  A,H        COMPARE SIGN
Ø46E AA                XOR  D
Ø46F 7A                LOD  A,D
Ø47Ø 19                ADD  HL,DE
Ø471 D1                POP  DE         RESTORE TEXT POINTER
Ø472 FA64Ø4            JMP  S,XP23     1ST 2ND SIGN DIFFER
Ø475 AC                XOR  H          1ST 2ND SIGN EQUAL
Ø476 F264Ø4            JMP  NS,XP23    SO IS RESULT
Ø479 C39FØØ            JMP  QHOW       ELSE WE HAVE OVERFLOW
Ø47C CF         XP25   TSTC '-',XP42   SUBTRACT?
Ø47D 2D
Ø47E 83
Ø47F E5         XP26   PUSH HL         YES, SAVE 1ST <EXPR3>
Ø48Ø CD89Ø4            CALL EXPR3      GET 2ND <EXPR3>
Ø483 CD6AØ5            CALL CHGSGN     NEGATE
Ø486 C36EØ4            JMP  XP24       AND ADD THEM
*
Ø489 CDE6Ø4     EXPR3  CALL EXPR4      GET 1ST <EXPR4>
Ø48C CF         XP31   TSTC '*',XP34   MULTIPLY?
Ø48D 2A
Ø48E 2C
Ø48F E5                PUSH HL         YES, SAVE 1ST
Ø49Ø CDE6Ø4            CALL EXPR4      AND GET 2ND <EXPR4>
Ø493 Ø6ØØ              LODI B,Ø        CLEAR B FOR SIGN
Ø495 CD67Ø5            CALL CHKSGN     CHECK SIGN
Ø498 EB                XCH  HL,DE      2ND IN DE NOW
```

```
Ø499 E3                     XCH  HL,(SP)    1ST IN HL
Ø49A CD67Ø5                 CALL CHKSGN     CHECK SIGN OF 1ST
Ø49D 7C                     LOD  A,H        IS HL > 255 ?
Ø49E B7                     IOR  A
Ø49F CAA8Ø4                 JMP  Z,XP32     NO
Ø4A2 7A                     LOD  A,D        YES, HOW ABOUT DE
Ø4A3 B2                     IOR  D
Ø4A4 EB                     XCH  HL,DE      PUT SMALLER IN HL
Ø4A5 C2AØØØ                 JMP  NZ,AHOW    ALSO >, WILL OVERFLOW
Ø4A8 7D             XP32    LOD  A,L        THIS IS DUMB
Ø4A9 21ØØØØ                 LODI HL,Ø       CLEAR RESULT
Ø4AC B7                     IOR  A          ADD AND COUNT
Ø4AD CAD8Ø4                 JMP  Z,XP35
Ø4BØ 19             XP33    ADD  HL,DE
Ø4B1 DAAØØØ                 JMP  C,AHOW     OVERFLOW
Ø4B4 3D                     DEC  A
Ø4B5 C2BØØ4                 JMP  NZ,XP33
Ø4B8 C3D8Ø4                 JMP  XP35       FINISHED
Ø4BB CF             XP34    TSTC '/',XP42   DIVIDE?
Ø4BC 2F
Ø4BD 44
Ø4BE E5                     PUSH HL         YES, SAVE 1ST <EXPR4>
Ø4BF CDE6Ø4                 CALL EXPR4      AND GET 2ND ONE
Ø4C2 Ø6ØØ                   LODI B,Ø        CLEAR B FOR SIGN
Ø4C4 CD67Ø5                 CALL CHKSGN     CHECK SIGN OF 2ND
Ø4C7 EB                     XCH  HL,DE      PUT 2ND IN DE
Ø4C8 E3                     XCH  HL,(SP)    GET 1ST IN HL
Ø4C9 CD67Ø5                 CALL CHKSGN     CHECK SIGN OF 1ST
Ø4CC 7A                     LOD  A,D        DIVIDE BY Ø?
Ø4CD B3                     IOR  E
Ø4CE CAAØØØ                 JMP  Z,AHOW     SAY "HOW?"
Ø4D1 C5                     PUSH BC         ELSE SAVE SIGN
Ø4D2 CD4AØ5                 CALL DIVIDE     USE SUBROUTINE
Ø4D5 6Ø69                   LOD  HL,BC      RESULT IN HL NOW
Ø4D7 C1                     POP  BC         GET SIGN BACK
Ø4D8 D1             XP35    POP  DE         AND TEXT POINTER
Ø4D9 7C                     LOD  A,H        HL MUST BE +
Ø4DA B7                     IOR  A
Ø4DB FA9FØØ                 JMP  S,QHOW     ELSE IT IS OVERFLOW
Ø4DE 78                     LOD  A,B
Ø4DF B7                     IOR  A
Ø4EØ FC6AØ5                 CALL S,CHGSGN   CHANGE SIGN IF NEEDED
Ø4E3 C38CØ4                 JMP  XP31       LOOK FOR MORE TERMS
*
Ø4E6 21AØØ1         EXPR4   LODI HL,TAB4-1  FIND FUNCTION IN TAB4
Ø4E9 C3F8Ø1                 JMP  EXEC       AND GO DO IT
Ø4EC FF             XP4Ø    TSTV            NO, NOT A FUNCTION
Ø4ED DAF5Ø4                 JMP  C,XP41     NOR A VARIABLE
Ø4FØ 7E                     LOD  A,M        VARIABLE
Ø4F1 23                     INC  HL
Ø4F2 66                     LOD  H,M        VALUE IN HL
Ø4F3 6F                     LOD  L,A
Ø4F4 C9                     RET  U
Ø4F5 CD77ØØ         XP41    CALL TSTNUM     OR IS IT A NUMBER
Ø4F8 78                     LOD  A,B        # OF DIGIT
Ø4F9 B7                     IOR  A
Ø4FA CØ                     RET  NZ         OK
Ø4FB CF             PARN    TSTC '(',XP43   NO DIGIT, MUST BE
Ø4FC 28
Ø4FD Ø5
```

```
Ø4FE DF                  EXPR           "(EXPR)"
Ø4FF CF                  TSTC ')',XP43
Ø5ØØ 29
Ø5Ø1 Ø1
Ø5Ø2 C9           XP42   RET  U
Ø5Ø3 C3A4Ø5       XP43   JMP  QWHAT     ELSE SAY: "WHAT?"
*
Ø5Ø6 CDFBØ4       RND    CALL PARN      *** RND(EXPR) ***
Ø5Ø9 7C                  LOD  A,H       EXPR MUST BE +
Ø5ØA B7                  IOR  A
Ø5ØB FA9FØØ              JMP  S,QHOW
Ø5ØE B5                  IOR  L         AND NON-ZERO
Ø5ØF CA9FØØ              JMP  Z,QHOW
Ø512 D5E5                PUSH DE,HL     SAVE BOTH
Ø514 2A11Ø8              LD   HL,RANPNT GET MEMORY AS RANDOM
Ø517 11FFØ7              LODI DE,LSTROM NUMBER
Ø51A E7                  COMP
Ø51B DA21Ø5              JMP  C,RA1     WRAP AROUND IF LAST
Ø51E 21ØØØØ              LODI HL,START
Ø521 5E           RA1    LOD  E,M
Ø522 23                  INC  HL
Ø523 56                  LOD  D,M
Ø524 2211Ø8              ST   HL,RANPNT
Ø527 E1                  POP  HL
Ø528 EB                  XCH  HL,DE
Ø529 C5                  PUSH BC
Ø52A CD4AØ5              CALL DIVIDE    RND(N)=MOD(M,N)+1
Ø52D C1D1                POP  BC,DE
Ø52F 23                  INC  HL
Ø53Ø C9                  RET  U
*
Ø531 CDFBØ4       ABS    CALL PARN      *** ABS(EXPR) ***
Ø534 CD67Ø5              CALL CHKSGN    CHECK SIGN
Ø537 7C                  LOD  A,H       NOTE THAT -32768
Ø538 B4                  IOR  H         CANNOT CHANGE SIGN
Ø539 FA9FØØ              JMP  S,QHOW    SO SAY: "HOW?"
Ø53C C9                  RET  U
Ø53D 2A13Ø8       SIZE   LD   HL,TXTUNF *** SIZE ***
Ø54Ø D5                  PUSH DE        GET THE NUMBER OF FREE
Ø541 EB                  XCH  HL,DE     BYTES BETWEEN 'TXTUNF'
Ø542 21ØØ1F @@@@         LODI HL,VARBGN AND 'VARBGN'
Ø545 CD6ØØ5              CALL SUBDE
Ø548 D1                  POP  DE
Ø549 C9                  RET  U
*
**************************************************************
*
* *** DIVIDE *** SUBDE *** CHKSGN *** CHGSGN *** & CKHLDE ***
*
* 'DIVIDE' DIVIDES HL BY DE, RESULT IN BC, REMAINDER IN HL
*
* 'SUBDE' SUBTRACTS DE FROM HL
*
* 'CHKSGN' CHECKS SIGN OF HL.  IF +, NO CHANGE.  IF -, CHANGE
* SIGN AND FLIP SIGN OF B.
*
* 'CHGSGN' CHNGES SIGN OF HL AND B UNCONDITIONALLY.
*
* 'CKHLDE' CHECKS SIGN OF HL AND DE.  IF DIFFERENT, HL AND DE
* ARE INTERCHANGED.  IF SAME SIGN, NOT INTERCHANGED.  EITHER
```

```
* CASE, HL DE ARE THEN COMPARED TO SET THE FLAGS.
*
Ø54A E5           DIVIDE PUSH HL        *** DIVIDE ***
Ø54B 6C                  LOD  L,H       DIVIDE H BY DE
Ø54C 26ØØ                LODI H,Ø
Ø54E CD55Ø5              CALL DV1
Ø551 41                  LOD  B,C       SAVE RESULT IN B
Ø552 7D                  LOD  A,L       (REMAINDER+L)/DE
Ø553 E1                  POP  HL
Ø554 67                  LOD  H,A
Ø555 ØEFF         DV1    LODI C,-1      RESULT IN C
Ø557 ØC           DV2    INC  C         DUMB ROUTINE
Ø558 CD6ØØ5              CALL SUBDE     DIVIDE BY SUBTRACT
Ø55B D257Ø5              JMP  NC,DV2    AND COUNT
Ø55E 19                  ADD  HL,DE
Ø55F C9                  RET  U
*
Ø56Ø 7D           SUBDE  LOD  A,L       *** SUBDE ***
Ø561 93                  SUB  E         SUBTRACT DE FROM
Ø562 6F                  LOD  L,A       HL
Ø563 7C                  LOD  A,H
Ø564 9A                  SBB  D
Ø565 67                  LOD  H,A
Ø566 C9                  RET  U
*
Ø567 7C           CHKSGN LOD  A,H       *** CHKSGN ***
Ø568 B7                  IOR  A         CHECK SIGN OF HL
Ø569 FØ                  RET  NS        IF -, CHANGE SIGN
*
Ø56A 7C           CHGSGN LOD  A,H       *** CHGSGN ***
Ø56B 2F                  CMA  ,         CHANGE SIGN OF HL
Ø56C 67                  LOD  H,A
Ø56D 7D                  LOD  A,L
Ø56E 2F                  CMA  ,
Ø56F 6F                  LOD  L,A
Ø57Ø 23                  INC  HL
Ø571 78                  LOD  A,B       AND ALSO FLIP B
Ø572 EE8Ø                XORI X'8Ø'
Ø574 47                  LOD  B,A
Ø575 C9                  RET  U
*
Ø576 7C           CKHLDE LOD  A,H
Ø577 AA                  XOR  D         SAME SIGN?
Ø578 F27CØ5              JMP  NS,CK1    YES, COMPARE
Ø57B EB                  XCH  HL,DE     NO, XCH AND COMP
Ø57C E7           CK1    COMP
Ø57D C9                  RET  U
*
**************************************************************
*
* *** SETVAL *** FIN *** ENDCHK *** & ERROR (& FRIENDS) ***
*
* "SETVAL" EXPECTS A VARIABLE, FOLLOWED BY AN EQUAL SIGN AND
* THEN AN EXPR.  IT EVALUATES THE EXPR. AND SET THE VARIABLE
* TO THAT VALUE.
*
* "FIN" CHECKS THE END OF A COMMAND.  IF IT ENDED WITH ";",
* EXECUTION CONTINUES.  IF IT ENDED WITH A CR, IT FINDS THE
* NEXT LINE AND CONTINUE FROM THERE.
*
```

```
* "ENDCHK" CHECKS IF A COMMAND IS ENDED WITH CR.  THIS IS
* REQUIRED IN CERTAIN COMMANDS. (GOTO, RETURN, AND STOP ETC.)
*
* "ERROR" PRINTS THE STRING POINTED BY DE (AND ENDS WITH CR).
* IT THEN PRINTS THE LINE POINTED BY 'CURRNT' WITH A "?"
* INSERTED AT WHERE THE OLD TEXT POINTER (SHOULD BE ON TOP
* OF THE STACK) POINTS TO.  EXECUTION OF TB IS STOPPED
* AND TBI IS RESTARTED.  HOWEVER, IF 'CURRNT' -> ZERO
* (INDICATING A DIRECT COMMAND), THE DIRECT COMMAND IS NOT
* PRINTED.  AND IF 'CURRNT' -> NEGATIVE # (INDICATING 'INPUT'
* COMMAND, THE INPUT LINE IS NOT PRINTED AND EXECUTION IS
* NOT TERMINATED BUT CONTINUED AT 'INPERR'.
*
* RELATED TO 'ERROR' ARE THE FOLLOWING:
* 'QWHAT' SAVES TEXT POINTER IN STACK AND GET MESSAGE "WHAT?"
* 'AWHAT' JUST GET MESSAGE "WHAT?" AND JUMP TO 'ERROR'.
* 'QSORRY' AND 'ASORRY' DO SAME KIND OF THING.
* 'QHOW' AND 'AHOW' IN THE ZERO PAGE SECTION ALSO DO THIS
*
Ø57E FF           SETVAL TSTV            *** SETVAL ***
Ø57F DAA4Ø5              JMP  C,QWHAT    "WHAT?" NO VARIABLE
Ø582 E5                  PUSH HL         SAVE ADDRESS OF VAR.
Ø583 CF                  TSTC '=',SV1    PASS "=" SIGN
Ø584 3D
Ø585 Ø8
Ø586 DF                  EXPR            EVALUATE EXPR.
Ø587 444D                LOD  BC,HL      VALUE IN BC NOW
Ø589 E1                  POP  HL         GET ADDRESS
Ø58A 71                  LOD  M,C        SAVE VALUE
Ø58B 23                  INC  HL
Ø58C 7Ø                  LOD  M,B
Ø58D C9                  RET  U
Ø58E C3A4Ø5       SV1    JMP  QWHAT      NO "=" SIGN
*
Ø591 CF           FIN    TSTC ';',FI1    *** FIN ***
Ø592 3B
Ø593 Ø4
Ø594 F1                  POP  AF         ";", PURGE RET. ADDR.
Ø595 C349Ø2              JMP  RUNSML     CONTINUE SAME LINE
Ø598 CF           FI1    TSTC @CR,FI2    NOT ";", IS IT CR?
Ø599 ØD
Ø59A Ø4
Ø59B F1                  POP  AF         YES, PURGE RET. ADDR.
Ø59C C339Ø2              JMP  RUNNXL     RUN NEXT LINE
Ø59F C9           FI2    RET  U          ELSE RETURN TO CALLER
*
Ø5AØ EF           ENDCHK IGNBLK          *** ENDCHK ***
Ø5A1 FEØD                CMPI @CR        END WITH CR?
Ø5A3 C8                  RET  Z          OK, ELSE SAY: "WHAT?"
*
Ø5A4 D5           QWHAT  PUSH DE         *** QWHAT ***
Ø5A5 11AEØØ       AWHAT  LODI DE,WHAT    *** AWHAT ***
Ø5A8 97           ERROR  SUB  A          *** ERROR ***
Ø5A9 CD3CØ6              CALL PRTSTG     PRINT 'WHAT?', 'HOW?'
Ø5AC D1                  POP  DE         OR 'SORRY'
Ø5AD 1A                  LD   A,(DE)     SAVE THE CHARACTER
Ø5AE F5                  PUSH AF         AT WHERE OLD DE ->
Ø5AF 97                  SUB  A          AND PUT A Ø THERE
Ø5BØ 12                  ST   A,(DE)
Ø5B1 2AØ1Ø8              LD   HL,CURRNT GET CURRENT LINE #
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```
Ø5B4 E5                  PUSH HL
Ø5B5 7E                  LOD  A,M        CHECK THE VALUE
Ø5B6 23                  INC  HL
Ø5B7 B6                  IOR  M
Ø5B8 D1                  POP  DE
Ø5B9 CAØØØØ              JMP  Z,START    IF ZERO, JUST RESTART
Ø5BC 7E                  LOD  A,M        IF NEGATIVE,
Ø5BD B7                  IOR  A
Ø5BE FAA7Ø3              JMP  S,INPERR   REDO INPUT
Ø5C1 CDAAØ6              CALL PRTLN      ELSE PRINT THE LINE
Ø5C4 1B                  DEC  DE         UPTO WHERE THE Ø IS
Ø5C5 F1                  POP  AF         RESTORE THE CHARACTER
Ø5C6 12                  ST   A,(DE)
Ø5C7 3E3F                LODI A,'?'      PRINT A "?"
Ø5C9 D7                  OUTC
Ø5CA 97                  SUB  A          AND THE REST OF THE
Ø5CB CD3CØ6              CALL PRTSTG     LINE
Ø5CE C7                  RSTART          THEN RESTART
Ø5CF D5           QSORRY PUSH DE         *** QSORRY ***
Ø5DØ 11B4ØØ       ASORRY LODI DE,SORRY   *** ASORRY ***
Ø5D3 C3A8Ø5              JMP  ERROR
*
******************************************************************
*
* *** GETLN *** FNDLN (& FRIENDS) ***
*
* 'GETLN' READS A INPUT LINE INTO 'BUFFER'.  IT FIRST PROMPT
* THE CHARACTER IN A (GIVEN BY THE CALLER), THEN IT FILLS THE
* THE BUFFER AND ECHOS.  IT IGNORES LF'S AND NULLS, BUT STILL
* ECHOS THEM BACK.  RUB-OUT IS USED TO CAUSE IT TO DELETE
* THE LAST CHARATER (IF THERE IS ONE), AND ALT-MOD IS USED TO
* CAUSE IT TO DELETE THE WHOLE LINE AND START IT ALL OVER.
* CR SIGNALS THE END OF A LINE, AND CAUSE 'GETLN' TO RETURN.
*
* 'FNDLN' FINDS A LINE WITH A GIVEN LINE # (IN HL) IN THE
* TEXT SAVE AREA.  DE IS USED AS THE TEXT POINTER.  IF THE
* LINE IS FOUND, DE WILL POINT TO THE BEGINNING OF THAT LINE
* (I.E., THE LOW BYTE OF THE LINE #), AND FLAGS ARE NC & Z.
* IF THAT LINE IS NOT THERE AND A LINE WITH A HIGHER LINE #
* IS FOUND, DE POINTS TO THERE AND FLAGS ARE NC & NZ.  IF
* WE REACHED THE END OF TEXT SAVE ARE AND CANNOT FIND THE
* LINE, FLAGS ARE C & NZ.
* 'FNDLN' WILL INITIALIZE DE TO THE BEGINNING OF THE TEXT SAVE
* AREA TO START THE SEARCH.  SOME OTHER ENTRIES OF THIS
* ROUTINE WILL NOT INITIALIZE DE AND DO THE SEARCH.
* 'FNDLNP' WILL START WITH DE AND SEARCH FOR THE LINE #.
* 'FNDNXT' WILL BUMP DE BY 2, FIND A CR AND THEN START SEARCH.
* 'FNDSKP' USE DE TO FIND A CR, AND THEN STRART SEARCH.
*
Ø5D6 D7           GETLN  OUTC            *** GETLN ***
Ø5D7 11371F @@@@         LODI DE,BUFFER  PROMPT AND INIT.
Ø5DA CD32Ø7       GL1    CALL CHKIO      CHECK KEYBOARD
Ø5DD CADAØ5              JMP  Z,GL1      NO INPUT, WAIT
Ø5EØ D7                  OUTC            INPUT, ECHO BACK
Ø5E1 FEØA                CMPI @LF        IGNORE LF
Ø5E3 CADAØ5              JMP  Z,GL1
Ø5E6 B7                  IOR  A          IGNORE NULL
Ø5E7 CADAØ5              JMP  Z,GL1
Ø5EA FE7F                CMPI @DLCH      DELETE LAST CHARACTER?
Ø5EC CAFFØ5              JMP  Z,GL3      YES
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Ø5EF FE7D               CMPI @DLLN      DELETE THE WHOLE LINE?
Ø5F1 CAØCØ5             JMP  Z,GL4      YES
Ø5F4 12                 ST   A,(DE)     ELSE, SAVE INPUT
Ø5F5 13                 INC  DE         AND BUMP POINTER
Ø5F6 FEØD               CMPI @CR        WAS IT CR?
Ø5F8 C8                 RET  Z          YES, END OF LINE
Ø5F9 7B                 LOD  A,E        ELSE, MORE FREE ROOM?
Ø5FA FE7F               CMPI BUFEND,>
Ø5FC C2DAØ5             JMP  NZ,GL1     YES, GET NEXT INPUT
Ø5FF 7B          GL3    LOD  A,E        DELETE LAST CHARACTER
Ø6ØØ FE37               CMPI BUFFER,>   BUT DO WE HAVE ANY?
Ø6Ø2 CAØCØ6             JMP  Z,GL4      NO, REDO WHOLE LINE
Ø6Ø5 1B                 DEC  DE         YES, BACKUP POINTER
Ø6Ø6 3E5C               LODI A,@BKS     AND ECHO A BACK-SLASH
Ø6Ø8 D7                 OUTC
Ø6Ø9 C3DAØ5             JMP  GL1        GO GET NEXT INPUT
Ø6ØC CDØEØØ      GL4    CALL CRLF       REDO ENTIRE LINE
Ø6ØF 3E5E               LODI A,@UPA     CR, LF AND UP-ARROW
Ø611 C3D6Ø5             JMP  GETLN
*
Ø614 7C          FNDLN  LOD  A,H        *** FNDLN ***
Ø615 B7                 IOR  A          CHECK SIGN OF HL
Ø616 FA9FØØ             JMP  S,QHOW     IT CANNOT BE -
Ø619 1115Ø8             LODI DE,TXTBGN  INIT. TEXT POINTER
*
Ø61C             FNDLNP EQU  *          *** FNDLNP ***
Ø61C E5          FL1    PUSH HL         SAVE LINE #
Ø61D 2A13Ø8             LD   HL,TXTUNF  CHECK IF WE PASSED END
Ø62Ø 2B                 DEC  HL
Ø621 E7                 COMP
Ø622 E1                 POP  HL         GET LINE # BACK
Ø623 D8                 RET  C          C,NZ PASSED END
Ø624 1A                 LD   A,(DE)     WE DID NOT, GET BYTE 1
Ø625 95                 SUB  L          IS THIS THE LINE?
Ø626 47                 LOD  B,A        COMPARE LOW ORDER
Ø627 13                 INC  DE  .
Ø628 1A                 LD   A,(DE)     GET BYTE 2
Ø629 9C                 SBB  H          COMPARE HIGH ORDER
Ø62A DA31Ø6             JMP  C,FL2      NO, NOT THERE YET
Ø62D 1B                 DEC  DE         ELSE WE EITHER FOUND
Ø62E BØ                 IOR  B          IT, OR IT IS NOT THERE
Ø62F C9                 RET  U          NC,Z:FOUND; NC,NZ:NO
*
Ø63Ø             FNDNXT EQU  *          *** FNDNXT ***
Ø63Ø 13                 INC  DE         FIND NEXT LINE
Ø631 13          FL2    INC  DE         JUST PASSED BYTE 1 & 2
*
Ø632 1A          FNDSKP LD   A,(DE)     *** FNDSKP ***
Ø633 FEØD               CMPI @CR        TRY TO FIND CR
Ø635 C231Ø6             JMP  NZ,FL2     KEEP LOOKING
Ø638 13                 INC  DE         FOUND CR, SKIP OVER
Ø639 C31CØ6             JMP  FL1        CHECK IF END OF TEXT
*
**************************************************************
*
* *** PRTSTG *** QTSTG *** PRTNUM *** & PRTLN ***
*
* 'PRTSTG' PRINTS A STRING POINTED BY DE.  IT STOPS PRINTING
* AND RETURNS TO CALLER WHEN EITHER A CR IS PRINTED OR WHEN
* THE NEXT BYTE IS THE SAME AS WHAT WAS IN A (GIVEN BY THE
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* CALLER).  OLD A IS STORED IN B, OLD B IS LOST.
*
* 'QTSTG' LOOKS FOR A BACK-ARROW, SINGLE QUOTE, OR DOUBLE
* QUOTE.  IF NONE OF THESE, RETURN TO CALLER.  IF BACK-ARROW,
* OUTPUT A CR WITHOUT A LF.  IF SINGLE OR DOUBLE QUOTE, PRINT
* THE STRING IN THE QUOTE AND DEMANDS A MATCHING UNQUOTE.
* AFTER THE PRINTING THE NEXT 3 BYTES OF THE CALLER IS SKIPPED
* OVER (USUALLY A JUMP INSTRUCTION).
*
* 'PRTNUM' PRINTS THE NUMBER IN HL.  LEADING BLANKS ARE ADDED
* IF NEEDED TO PAD THE NUMBER OF SPACES TO THE NUMBER IN C.
* HOWEVER, IF THE NUMBER OF DIGITS IS LARGER THAN THE # IN
* C, ALL DIGITS ARE PRINTED ANYWAY.  NEGATIVE SIGN IS ALSO
* PRINTED AND COUNTED IN, POSITIVE SIGN IS NOT.
*
* 'PRTLN' PRINTS A SAVED TEXT LINE WITH LINE # AND ALL.
*
Ø63C 47             PRTSTG LOD  B,A         *** PRTSTG ***
Ø63D 1A             PS1    LD   A,(DE)      GET A CHARACTER
Ø63E 13                    INC  DE          BUMP POINTER
Ø63F B8                    CMP  B           SAME AS OLD A?
Ø64Ø C8                    RET  Z           YES, RETURN
Ø641 D7                    OUTC             ELSE PRINT IT
Ø642 FEØD                  CMPI @CR         WAS IT A CR?
Ø644 C23DØ6                JMP  NZ,PS1      NO, NEXT
Ø647 C9                    RET  U           YES, RETURN
*
Ø648 CF             QTSTG  TSTC '"',QT3     *** QTSTG ***
Ø649 22
Ø64A ØF
Ø64B 3E22                  LODI A,'"'       IT IS A "
Ø64D CD3CØ6         QT1    CALL PRTSTG      PRINT UNTIL ANOTHER
Ø65Ø FEØD                  CMPI @CR         WAS LAST ONE A CR?
Ø652 E1                    POP  HL          RETURN ADDRESS
Ø653 CA39Ø2                JMP  Z,RUNNXL    WAS CR, RUN NEXT LINE
Ø656 232323         QT2    INC  HL,3        SKIP 3 BYTES ON RETURN
Ø659 E9                    JMP  (HL)        RETURN
Ø65A CF             QT3    TSTC @QT,QT4     IS IT A ' ?
Ø65B 27
Ø65C Ø5
Ø65D 3E27                  LODI A,@QT       YES, DO SAME
Ø65F C34DØ6                JMP  QT1         AS IN "
Ø662 CF             QT4    TSTC @BKA,QT5    IS IT BACK-ARROW?
Ø663 5F
Ø664 Ø8
Ø665 3E8D                  LODI A,X'8D'     YES, CR WITHOUT LF
Ø667 D7                    OUTC             DO IT TWICE TO GIVE
Ø668 D7                    OUTC             TTY ENOUGH TIME
Ø669 E1                    POP  HL          RETURN ADDRESS
Ø66A C356Ø6                JMP  QT2
Ø66D C9             QT5    RET  U           NONE OF ABOVE
*
Ø66E D5             PRTNUM PUSH DE          *** PRTNUM ***
Ø66F 11ØAØØ                LODI DE,1Ø       DECIMAL
Ø672 D5                    PUSH DE          SAVE AS A FLAG
Ø673 42                    LOD  B,D         B=SIGN
Ø674 ØD                    DEC  C           C=SPACES
Ø675 CD67Ø5                CALL CHKSGN      CHECK SIGN
Ø678 F27EØ6                JMP  NS,PN1      NO SIGN
Ø67B Ø62D                  LODI B,'-'       B=SIGN
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Ø67D ØD                  DEC  C         '-' TAKES SPACE
Ø67E C5           PN1    PUSH BC        SAVE SIGN & SPACE
Ø67F CD4AØ5       PN2    CALL DIVIDE    DEVIDE HL BY 1Ø
Ø682 78                  LOD  A,B       RESULT Ø?
Ø683 B1                  IOR  C
Ø684 CA8FØ6              JMP  Z,PN3     YES, WE GOT ALL
Ø687 E3                  XCH  HL,(SP)   NO, SAVE REMAINDER
Ø688 2D                  DEC  L         AND COUNT SPACE
Ø689 E5                  PUSH HL        HL IS OLD BC
Ø68A 6Ø69                LOD  HL,BC     MOVE RESULT TO BC
Ø68C C37FØ6              JMP  PN2       AND DIVIDE BY 1Ø
Ø68F C1           PN3    POP  BC        WE GOT ALL DIGITS IN
Ø69Ø ØD           PN4    DEC  C         THE STACK
Ø691 79                  LOD  A,C       LOOK AT SPACE COUNT
Ø692 B7                  IOR  A
Ø693 FA9CØ6              JMP  S,PN5     NO LEADING BLANKS
Ø696 3E2Ø                LODI A,' '     LEADING BLANKS
Ø698 D7                  OUTC
Ø699 C39ØØ6              JMP  PN4       MORE?
Ø69C 78           PN5    LOD  A,B       PRINT SIGN
Ø69D D7                  OUTC           MAYBE - OR NULL
Ø69E 5D                  LOD  E,L       LAST REMAINDER IN E
Ø69F 7B           PN6    LOD  A,E       CHECK DIGIT IN E
Ø6AØ FEØA                CMPI 1Ø        1Ø IS FLAG FOR NO MORE
Ø6A2 D1                  POP  DE
Ø6A3 C8                  RET  Z         IF SO, RETURN
Ø6A4 C63Ø                ADDI 'Ø'       ELSE COVERT TO ASCII
Ø6A6 D7                  OUTC           AND PRINT THE DIGIT
Ø6A7 C39FØ6              JMP  PN6       GO BACK FOR MORE
*
Ø6AA 1A           PRTLN  LD   A,(DE)    *** PRTLN ***
Ø6AB 6F                  LOD  L,A       LOW ORDER LINE #
Ø6AC 13                  INC  DE
Ø6AD 1A                  LD   A,(DE)    HIGH ORDER
Ø6AE 67                  LOD  H,A
Ø6AF 13                  INC  DE
Ø6BØ ØEØ4                LODI C,4       PRINT 4 DIGIT LINE #
Ø6B2 CD6EØ6              CALL PRTNUM
Ø6B5 3E2Ø                LODI A,' '     FOLLOWED BY A BLANK
Ø5B7 D7                  OUTC
Ø5B8 97                  SUB  A         AND THEN THE TEXT
Ø5B9 CD3CØ6              CALL PRTSTG
Ø6BC C9                  RET  U
*
**************************************************************
*
* *** MVUP *** MVDOWN *** POPA *** & PUSHA ***
*
* 'MVUP' MOVES A BLOCK UP FROM WHERE DE-> TO WHERE BC-> UNTIL
* DE = HL
*
* 'MVDOWN' MOVES A BLOCK DOWN FROM WHERE DE-> TO WHERE HL->
* UNTIL DE = BC
*
* 'POPA' RESTORES THE 'FOR' LOOP VARIABLE SAVE AREA FROM THE
* STACK
*
* 'PUSHA' STACKS THE 'FOR' LOOP VARIABLE SAVE AREA INTO THE
* STACK
*
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```
Ø6BD E7           MVUP   COMP           *** MVUP ***
Ø6BE C8                  RET  Z         DE = HL, RETURN
Ø6BF 1A                  LD   A,(DE)    GET ONE BYTE
Ø6CØ Ø2                  ST   A,(BC)    MOVE IT
Ø6C1 13                  INC  DE        INCREASE BOTH POINTERS
Ø6C2 Ø3                  INC  BC
Ø6C3 C3BDØ6              JMP  MVUP      UNTIL DONE
*
Ø6C6 78           MVDOWN LOD  A,B       *** MVDOWN ***
Ø6C7 92                  SUB  D         TEST IF DE = BC
Ø6C8 C2CEØ6              JMP  NZ,MD1    NO, GO MOVE
Ø6CB 79                  LOD  A,C       MAYBE, OTHER BYTE?
Ø6CC 93                  SUB  E
Ø6CD C8                  RET  Z         YES, RETURN
Ø6CE 1B           MD1    DEC  DE        ELSE MOVE A BYTE
Ø6CF 2B                  DEC  HL        BUT FIRST DECREASE
Ø6DØ 1A                  LD   A,(DE)    BOTH POINTERS AND
Ø6D1 77                  LOD  M,A       THEN DO IT
Ø6D2 C3C6Ø6              JMP  MVDOWN    LOOP BACK
*
Ø6D5 C1           POPA   POP  BC        BC = RETURN ADDR.
Ø6D6 E1                  POP  HL        RESTORE LOPVAR, BUT
Ø6D7 22Ø7Ø8              ST   HL,LOPVAR =Ø MEANS NO MORE
Ø6DA 7C                  LOD  A,H
Ø6DB B5                  IOR  L
Ø6DC CAEFØ6              JMP  Z,PP1     YEP, GO RETURN
Ø6DF E1                  POP  HL        NOP, RESTORE OTHERS
Ø6EØ 22Ø9Ø8              ST   HL,LOPINC
Ø6E3 E1                  POP  HL
Ø6E4 22ØBØ8              ST   HL,LOPLMT
Ø6E7 E1                  POP  HL
Ø6E8 22ØDØ8              ST   HL,LOPLN
Ø6EB E1                  POP  HL
Ø6EC 22ØFØ8              ST   HL,LOPPT
Ø6EF C5           PP1    PUSH BC        BC = RETURN ADDR.
Ø6FØ C9                  RET  U
*
Ø6F1 21A71F @@@@  PUSHA  LODI HL,STKLMT *** PUSHA ***
Ø6F4 CD6AØ5              CALL CHGSGN
Ø6F7 C1                  POP  BC        BC=RETURN ADDRESS
Ø6F8 39                  ADD  HL,SP     IS STACK NEAR THE TOP?
Ø6F9 D2CFØ5              JMP  NC,QSORRY YES, SORRY FOR THAT.
Ø6FC 2AØ7Ø8              LD   HL,LOPVAR ELSE SAVE LOOP VAR.S
Ø6FF 7C                  LOD  A,H       BUT IF LOPVAR IS Ø
Ø7ØØ B5                  IOR  L         THAT WILL BE ALL
Ø7Ø1 CA17Ø7              JMP  Z,PU1
Ø7Ø4 2AØFØ8              LD   HL,LOPPT  ELSE, MORE TO SAVE
Ø7Ø7 E5                  PUSH HL
Ø7Ø8 2AØDØ8              LD   HL,LOPLN
Ø7ØB E5                  PUSH HL
Ø7ØC 2AØBØ8              LD   HL,LOPLMT
Ø7ØF E5                  PUSH HL
Ø71Ø 2AØ9Ø8              LD   HL,LOPINC
Ø713 E5                  PUSH HL
Ø714 2AØ7Ø8              LD   HL,LOPVAR
Ø717 E5           PU1    PUSH HL
Ø718 C5                  PUSH BC        BC = RETURN ADDR.
Ø719 C9                  RET  U
*
*************************************************************
```

```
*
* *** OUTC *** & CHKIO ***
*
* THESE ARE THE ONLY I/O ROUTINES IN TBI.
* 'OUTC' IS CONTROLLED BY A SOFTWARE SWITCH 'OCSW'.  IF OCSW=Ø
* 'OUTC' WILL JUST RETURN TO THE CALLER.  IF OCSW IS NOT Ø,
* IT WILL OUTPUT THE BYTE IN A.  IF THAT IS A CR, A LF IS ALSO
* SEND OUT.  ONLY THE FLAGS MAY BE CHANGED AT RETURN, ALL REG.
* ARE RESTORED.
*
* 'CHKIO' CHECKS THE INPUT.  IF NO INPUT, IT WILL RETURN TO
* THE CALLER WITH THE Z FLAG SET.  IF THERE IS INPUT, Z FLAG
* IS CLEARED AND THE INPUT BYTE IS IN A.  HOWERER, IF THE
* INPUT IS A CONTROL-O, THE 'OCSW' SWITCH IS COMPLIMENTED, AND
* Z FLAG IS RETURNED.  IF A CONTROL-C IS READ, 'CHKIO' WILL
* RESTART TBI AND DO NOT RETURN TO THE CALLER.
*
*                      OUTC.   PUSH AF        THIS IS AT LOC. 1Ø
*                              LD   A,OCSW    CHECK SOFTWARE SWITCH
*                              IOR  A
Ø71A C21FØ7            OC2     JMP  NZ,OC3    IT IS ON
Ø71D F1                        POP  AF        IT IS OFF
Ø71E C9                        RET  U         RESTORE AF AND RETURN
Ø71F DBØØ              OC3     INP  Ø         COME HERE TO DO OUTPUT
Ø721 E6Ø2                      ANDI X'Ø2'     STATUS BIT
Ø723 CA1FØ7                    JMP  Z,OC3     NOT READY, WAIT
Ø726 F1                        POP  AF        READY, GET OLD A BACK
Ø727 D3Ø1                      OUT  1         AND SEND IT OUT
Ø729 FEØD                      CMPI @CR       WAS IT CR?
Ø72B CØ                        RET  NZ        NO, FINISHED
Ø72C 3EØA                      LODI A,@LF     YES, WE SEND LF TOO
Ø72E D7                        OUTC           THIS IS RECURSIVE
Ø72F 3EØD                      LODI A,@CR     GET CR BACK IN A
Ø731 C9                        RET  U
Ø732 DBØØ              CHKIO   INP  Ø         *** CHKIO ***
Ø734 ØØ                        NOP  ,         STATUS BIT FLIPPED?
Ø735 E62Ø                      ANDI X'2Ø'     MASK STATUS BIT
Ø737 C8                        RET  Z         NOT READY, RETURN "Z"
0738 DBØ1                      INP  1         READY, READ DATA
Ø73A E67F                      ANDI X'7F'     MASK BIT 7 OFF
Ø73C FEØF                      CMPI @CO       IS IT CONTROL-O?
Ø73E C24BØ7                    JMP  NZ,CI1    NO, MORE CHECKING
Ø741 3AØØØ8                    LD   A,OCSW    CONTROL-O FLIPS OCSW
Ø744 2F                        CMA  ,         ON TO OFF, OFF TO ON
Ø745 32ØØØ8                    ST   A,OCSW
Ø748 C332Ø7                    JMP  CHKIO     GET ANOTHER INPUT
Ø74B FEØ3              CI1     CMPI @CC       IS IT CONTROL-C?
Ø74D CØ                        RET  NZ        NO, RETURN "NZ"
Ø74E C7                        RSTART         YES, RESTART TBI
Ø74F 594F552Ø4D41592Ø          CHAR 'YOU MAY NEED THIS SPACE TO'
Ø757 4E4545442Ø544849
Ø75F 532Ø535Ø4143452Ø
Ø767 544F
Ø769 5Ø4154434820555Ø          CHAR 'PATCH UP THE I/O ROUTINES,'
Ø771 2Ø5448452Ø492F4F
Ø779 2Ø524F555449 4E45
Ø781 532C
0783 544F2Ø4649582Ø55          CHAR 'TO FIX UP BUGS, OR TO ADD'
Ø78B 5Ø2Ø425547532C2Ø
Ø793 4F522Ø544F2Ø4144
```

```
Ø79B 44
Ø79C 4D4F524520434F4D    CHAR 'MORE COMMANDS AND FUNCTIONS.'
Ø7A4 4D414E445320414E
Ø7AC 442Ø46554E435449
Ø7B4 4F4E532E
Ø7B8 534B592Ø28535Ø41    CHAR 'SKY (SPACE) IS THE LIMIT.'
Ø7CØ 4345292Ø49532Ø54
Ø7C8 4845204C494D4954
Ø7DØ 2E
Ø7D1 474F4F442Ø4C5543    CHAR 'GOOD LUCK AND GOOD BYE.'
Ø7D9 4B2Ø414E442Ø474F
Ø7E1 4F442Ø42594552E
Ø7E8 4C494348454E2Ø57    CHAR 'LICHEN WANG, 1Ø JUNE 76'
Ø7FØ 414E472C2Ø313Ø2Ø
Ø7F8 4A554E45203736
Ø7FF              LSTROM EQU  *         ALL ABOVE CAN BE ROM
                         ORG  X'Ø8ØØ'   HERE DOWN MUST BE RAM
Ø8ØØ FF           OCSW   DB   X'FF'     SWITCH FOR OUTPUT
Ø8Ø1 ØØØØ         CURRNT DW   Ø         POINTS TO CURRENT LINE
Ø8Ø3 ØØØØ         STKGOS DW   Ø         SAVES SP IN 'GOSUB'
Ø8Ø5              VARNXT EOU  *         TEMP STORAGE
Ø8Ø5 ØØØØ         STKINP DW   Ø         SAVES SP IN 'INPUT'
Ø8Ø7 ØØØØ         LOPVAR DW   Ø         'FOR' LOOP SAVE AREA
Ø8Ø9 ØØØØ         LOPINC DW   Ø         INCREMENT
Ø8ØB ØØØØ         LOPLMT DW   Ø         LIMIT
Ø8ØD ØØØØ         LOPLN  DW   Ø         LINE NUMBER
Ø8ØF ØØØØ         LOPPT  DW   Ø         TEXT POINTER
Ø811 ØØØØ         RANPNT DW   START     RANDOM NUMBER POINTER
Ø813 15Ø8         TXTUNF DW   TXTBGN    ->UNFILLED TEXT AREA
Ø815 C5           TXTBGN DS   1         TEXT SAVE AREA BEGINS
1FØØ              TXTEND EQU  VARBGN    TEXT SAVE AREA ENDS
                         ORG  X'1FØØ'
1FØØ              VARBGN DS   2*27      VARIABLE @(Ø)
1F36                     DS   XL1       EXTRA BYTE FOR BUFFER
1F37              BUFFER DS   XL72      INPUT BUFFER
1F7F              BUFEND EQU  *         BUFFER ENDS
1F7F                     DS   XL4Ø      EXTRA BYTES FOR STACK
1FA7              STKLMT EQU  *         TOP LIMIT FOR STACK
                         ORG  X'2ØØØ'
2ØØØ              STACK  EOU  *         STACK STARTS HERE
                         END
```

```
                       ;
                       ;      MODIFY TINY BASIC TABLE TO INCLUDE THIS
                       ;      COMMAND
                       ;
0181                          ORG 0181H
0181 5350454543               DB 'SPEECH'         ;SPEECH COMMAND
0187 874F                     DB 087H,04FH        ;ENTRY POINT TO PATCH
0189 8401                     DB 084H,01H         ;DEFAULT ENTRY POINT
                       ;
074F DF                START: RST 3               ;EXPR
0750 22D607                   SHLD SAMPS          ;NO. OF SAMPLES
0753 CF                       RST 1               ;LOOK FOR COMMA
0754 2C                       DB ','
0755 0B                       DCX B
0756 DF                       RST 3               ;EXPR
0757 22D807                   SHLD PERIOD         ;SAMPLE PERIOD
075A CDA005                   CALL ENDCHK         ;SHOULD BE END OF STATEMENT
075D CD6407                   CALL SPCH           ;GET SPEECH DATA
0760 F7                       RST 6               ;FINISH
0761 C3A405                   JMP QWHAT           ;DIDN'T FINISH COMMAND PROPERLY

0764 F5                SPCH:  PUSH PSW            ;SAVE REGISTERS
0765 C5                       PUSH B
0766 D5                       PUSH D
0767 3EFA                     MVI A,250           ;PAUSE FOR TTY NOISE
0769 CDA107                   CALL DELAY
076C CDC607                   CALL BEEP           ;SIGNAL BEGINNING OF WINDOW
076F 3E96                     MVI A,150           ;DELAY FOR BEEPER NOISE
0771 CDA107                   CALL DELAY
0774 21001F                   LXI H,VARBGN        ; @@@@ BASE OF @(0) CHANGE FOR LARGER
                       ;                           SYSTEMS
0777 3AD607                   LDA SAMPS           ;NO. OF SAMPLES TO TAKE
077A 5F                       MOV E,A
077B 1600              SP00:  MVI D,0
077D 7A                SP0:   MOV A,D
077E FE04                     CPI 4
0780 CA9007                   JZ SP1              ;FINISHED 1 SAMPLE, 4 BANDS
```

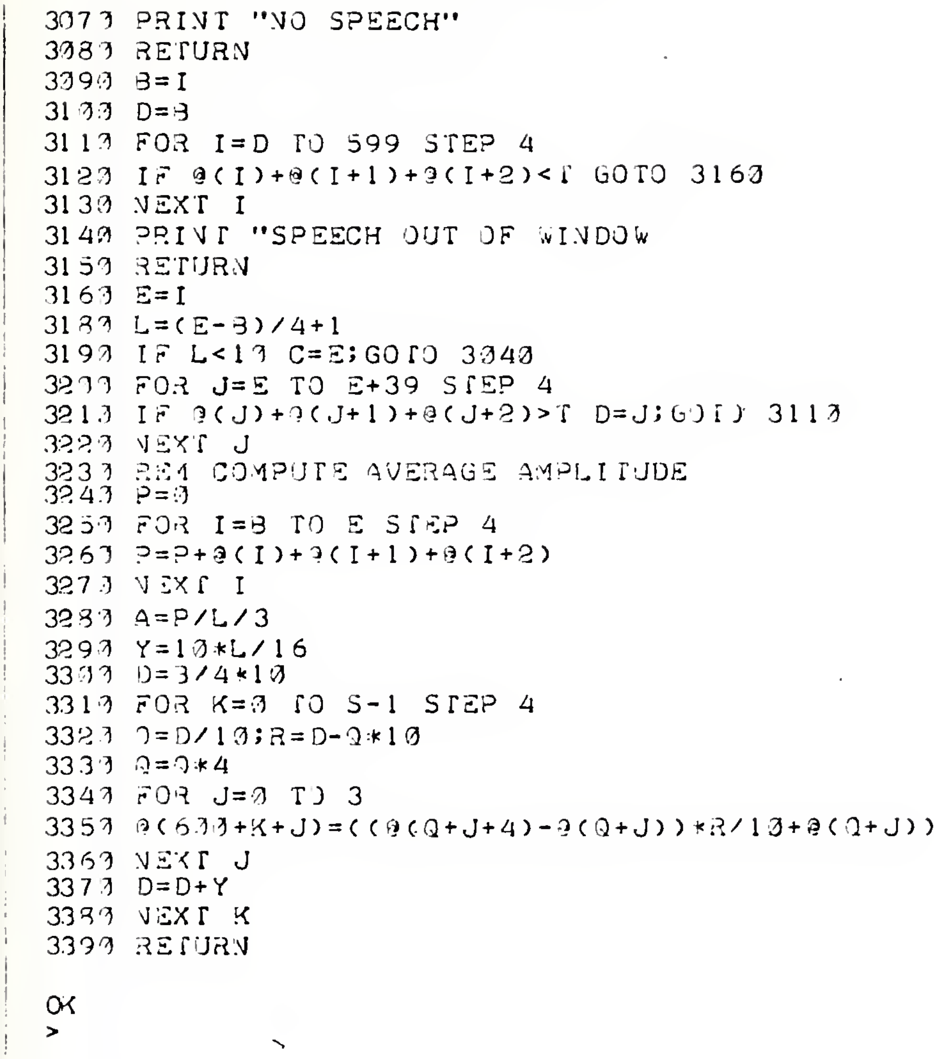
```
0783 CDB507             CALL GET1          ;NO, GET ANOTHER BAND
0786 77                 MOV M,A            ;STORE SAMPLE
0787 2B                 DCX H              ;ARRAY STORED BACKWARDS
0788 3E00               MVI A,0            ;0 HI ORDER HALF OF WORD
078A 77                 MOV M,A
078B 2B                 DCX H
078C 14                 INR D              ;UP BAND NO.
078D C37D07             JMP SP0
0790 3AD807     SP1:    LDA PERIOD
0793 CDA107             CALL DELAY         ;PAUSE BETWEEN SAMPLES
0796 1D                 DCR E              ;SAMPLES TO GO
0797 C27B07             JNZ SP00           ;MORE?
079A CDC607             CALL BEEP          ;NO-- END WINDOW
079D D1                 POP D              ;RESTORE REGISTERS
079E C1                 POP B
079F F1                 POP PSW
07A0 C9                 RET

07A1 C5         DELAY:  PUSH B             ;SAVE B
07A2 FE00       DEL0:   CPI 0              ;FINISHED?
07A4 CAB307             JZ RETDEL
07A7 0669               MVI B,105          ;MAGIC CONSTANT
07A9 00         DEL1:   NOP                ;KILL TIME
07AA 00                 NOP
07AB 05                 DCR B
07AC C2A907             JNZ DEL1
07AF 3D                 DCR A              ;1 MS GONE
07B0 C3A207             JMP DEL0
07B3 C1         RETDEL: POP B              ;RESTORE REGISTER B
07B4 C9                 RET
                ;
```

```
07B5 F620       GET1:    ORI 020H          ;DISABLE SWITCH
07B7 D3AF                OUT 0AFH          ;DO IT
07B9 E6DF                ANI 0DFH          ;CLEAR OUT DISABLE BITS
07BB D3AF                OUT 0AFH          ;REENABLE SWITCH
07BD DBAF       GET2:    IN 0AFH           ;GET STATUS
07BF 17                  RAL
07C0 DABD07              JC GET2           ;CARRY MEANS NOT READY
07C3 DBAF                IN 0AFH           ;GET DATA
07C5 C9                  RET

07C6 F5         BEEP:    PUSH PSW
07C7 3E10                MVI A,010H        ;TURN ON BEEPER
07C9 D3AF                OUT 0AFH
07CB 3E64                MVI A,100         ;LEAVE IT ON 100MS
07CD CDA107              CALL DELAY
07D0 3E00                MVI A,0           ;TURN BEEPER OFF
07D2 D3AF                OUT 0AFH
07D4 F1                  POP PSW
07D5 C9                  RET
                ;
07D6            SAMPS:   DS 2              ;NO. OF SAMPLES
07D8            PERIOD:  DS 2              ;DELAY BETWEEN SAMPLES
                ;
```

```
  1Ø REM ENHANCED SPEECH RECOGNITION PROGRAM
  2Ø REM --- PROGRAM 1 ---
  25 REM --- MOD ALLOWS USER TO KEEP WORD TABLES
  26 REM --- AS DESIRED.
  3Ø V=1Ø
  31 INPUT "CLEAR TABLES?;1 FOR YES,2 FOR NO"X
  32 IF X = 2 GOTO 1ØØ
  35 REM CLEAR TABLES
  4Ø FOR I=Ø TO 64*V-1
  5Ø @(7ØØ+I)=Ø
  6Ø NEXT I
 1ØØ T=6
 12Ø INPUT "1=T,2=P"X
 14Ø IF X # 1 GOTO 17Ø
 15Ø GOSUB 1ØØØ
 16Ø GOTO 12Ø
 17Ø IF X # 2 GOTO 2ØØ
 18Ø GOSUB 2ØØØ
 19Ø PRINT "RECOGNIZED:",N
 2ØØ GOTO 12Ø
 21Ø PRINT "?"
 22Ø GOTO 12Ø
1ØØØ REM TRAINING ROUTINE
1Ø1Ø INPUT "NUMBER"N
1Ø15 IF N>V PRINT "?" GOTO 1Ø1Ø
1Ø2Ø REM GET SPEECH
1Ø3Ø GOSUB 3ØØØ
1Ø4Ø REM GET 64 PARAMETERS
1Ø5Ø S=64
1Ø6Ø FOR J=Ø TO S-1
1Ø7Ø @(7ØØ+N*S+J)=@(6ØØ+J)
1Ø8Ø NEXT J
1Ø9Ø RETURN
2ØØØ REM PERFORMANCE ROUTINE
2Ø1Ø GOSUB 3ØØØ
2Ø2Ø FOR I=664 TO 663+V
2Ø4Ø @(I)=Ø
2Ø5Ø NEXT I
2Ø6Ø FOR I=Ø TO V-1
2Ø7Ø FOR J=Ø TO S-1
2Ø8Ø X=ABS(@(6ØØ+J)-@(7ØØ+S*I+J))
2Ø9Ø IF @(664+I)<275ØØ @(664+I)=@(664+I)+X*X
21ØØ NEXT J
212Ø NEXT I
213Ø REM FIND SMALLEST DIFFERENCE
214Ø A=32ØØØ,N=Ø
215Ø FOR I=Ø TO 9
216Ø IF @(664+I)<A A=@(664+I);N=I
217Ø NEXT I
218Ø RETURN
3ØØØ REM SPEECH COLLECTION ROUTINE
3Ø1Ø C=Ø
3Ø2Ø SPEECH 15Ø,1Ø
3Ø3Ø T=6
3Ø4Ø FOR I=C TO 599 STEP 4
3Ø5Ø IF @(I)+@(I+1)+@(I+2)>T GOTO 3Ø9Ø
3Ø6Ø NEXT I
```



```
3070 PRINT "NO SPEECH"
3080 RETURN
3090 B=I
3100 D=B
3110 FOR I=D TO 599 STEP 4
3120 IF @(I)+@(I+1)+@(I+2)<T GOTO 316Ø
3130 NEXT I
3140 PRINT "SPEECH OUT OF WINDOW
3150 RETURN
3160 E=I
3180 L=(E-B)/4+1
3190 IF L<10 C=E;GOTO 3Ø4Ø
3200 FOR J=E TO E+39 STEP 4
3210 IF @(J)+@(J+1)+@(J+2)>T D=J;GOTO 311Ø
3220 NEXT J
3230 REM COMPUTE AVERAGE AMPLITUDE
3240 P=Ø
3250 FOR I=B TO E STEP 4
3260 P=P+@(I)+@(I+1)+@(I+2)
3270 NEXT I
3280 A=P/L/3
3290 Y=1Ø*L/16
3300 D=B/4*1Ø
3310 FOR K=Ø TO S-1 STEP 4
3320 Q=D/1Ø;R=D-Q*1Ø
3330 Q=Q*4
3340 FOR J=Ø TO 3
3350 @(6ØØ+K+J)=((@(Q+J+4)-@(Q+J))*R/1Ø+@(Q+J))
3360 NEXT J
3370 D=D+Y
3380 NEXT K
3390 RETURN

OK
>
```

The following changes are required to convert Program 1 to Program 2, which utilizes Polynomial Regression along with the Euclidian Distance measure of Program 1:

(1) Add line 105   105 INPUT F

(2) Change line 2090 to read:

```
2090 IF @(664+I)<27500 @(664+I) = @(664+I)+X*X-F*X
```

```
                                                     PAGE 01

ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

3700            0010 *  CSRMON
3700            0020 *
3700            0030 *  KEYBOARD INPUT CONTROLLER TO CALL CSR1
3700            0040 *
3700            0050 *  LLOYD RICE, COMPUTALKER CONSULTANTS
3700            0060 *  VERSION 1.06   MAY 30, 1977
3700            0070 *
3700            0080 *  DEFINE INPUT STRING BUFFER LENGTH
3700            0090 INBFLN     EQU   76
3700            0100 *
3700 31 00 20   0110 CSRMON     LXI   SP,2000H * THIS IS THE ONLY STACK INSTR
3703 21 94 37   0120            LXI   H,MSG1
3706 CD 7D 37   0130 DSP0       CALL  DISPLA   * DISPLAY HEADING AND CUE
3709 3E 0D      0140            MVI   A,0DH    * THEN ANOTHER CR
370B CD D8 38   0150 DSP1       CALL  CHROUT
370E 21 B4 37   0160            LXI   H,BUFF
3711 0E 4A      0170            MVI   C,INBFLN-2
3713 CD 6F 37   0180 CHLOOP     CALL  CHRIN    * READ A CHAR FROM KBD
3716 E6 7F      0190            ANI   7FH
3718 FE 20      0200            CPI   ' '
371A DA 32 37   0210            JC    CTRL
371D FE 5B      0220            CPI   'Z'+1
371F D2 63 37   0230            JNC   GTZ
3722 0D         0240            DCR   C
3723 C2 2A 37   0250            JNZ   DSP2-2
3726 0C         0260            INR   C
3727 C3 13 37   0270            JMP   CHLOOP
372A 77         0280            MOV   M,A
372B 23         0290            INX   H
372C CD D8 38   0300 DSP2       CALL  CHROUT   * DISPLAY THE CHAR
372F C3 13 37   0310            JMP   CHLOOP   * GET ANOTHER
3732            0320 *
3732 FE 18      0330 CTRL       CPI   18H      * CTRL X
3734 CA 0B 37   0340            JZ    DSP1     * ECHO IT TO CLEAR THE SCREEN
3737 FE 10      0350            CPI   10H      * CTRL P
3739 CA 59 37   0360            JZ    REPLAY   * PLAY THE LAST ONE AGAIN
373C FE 02      0370            CPI   2        * CTRL B
373E CA 4B 38   0380            JZ    BUFDIS   * DUMP THE BUFFER
3741 FE 0D      0390            CPI   0DH
3743 C2 13 37   0400            JNZ   CHLOOP   * IGNORE ALL ELSE BUT CR
3746 77         0410            MOV   M,A
3747 CD D8 38   0420            CALL  CHROUT   * ECHO THE RETURN
374A 21 B4 37   0430            LXI   H,BUFF
374D CD 00 20   0440            CALL  CSR1     * COMPUTE AND SAY IT
3750 C4 88 37   0450            CNZ   ERROUT   * SOMPIN' HAPND, WRITE ERR MSG
3753 21 A6 37   0460 CUE1       LXI   H,MSG2
3756 C3 06 37   0470            JMP   DSP0
3759            0480 *
3759 E5         0490 REPLAY     PUSH  H
375A C5         0500            PUSH  B
375B CD 03 20   0510            CALL  PLAY     * PLAY THE LAST ONE AGAIN
375E C1         0520            POP   B
375F E1         0530            POP   H
3760 C3 13 37   0540            JMP   CHLOOP
3763            0550 *
3763 FE 7F      0560 GTZ        CPI   7FH      * CHAR > 'Z', CHECK FOR RUBOUT
3765 C2 13 37   0570            JNZ   CHLOOP
```

```
                                                            PAGE 02

ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

3768 0D           0580            DCR   C
3769 2B           0590            DCX   H
376A 00           0600            NOP   *         * MVI A,XX  WITH CHAR TO ECHO
376B 00           0610            NOP   *         *    ON RUBOUT (IF NOT 7FH)
376C C3 2C 37     0620            JMP   DSP2
376F              0630 *
376F              0640 *  CHAR INPUT (CALLED FOR CONSOLE KBD INPUT)
376F CD 73 37     0650 CHRIN      CALL  TTYIN    * REDEFINE AS NEEDED
3772 C9           0660            RET
3773              0670 *
3773              0680 *  TTY INPUT HANDLER
3773 DB 00        0690 TTYIN      IN    0
3775 E6 80        0700            ANI   80H
3777 CA 73 37     0710            JZ    $-4
377A DB 01        0720            IN    1
377C C9           0730            RET
377D              0740 *
377D              0750 *  MESSAGE OUTPUT LOOP, STOP ON CHAR=04
377D              0760 *
377D 7E           0770 DISPLA     MOV   A,M      * GET CHAR
377E FE 04        0780            CPI   4
3780 C8           0790            RZ    *        * RETURN IF EOT
3781 CD D8 38     0800            CALL  CHROUT   * NO, OUTPUT IT
3784 23           0810            INX   H
3785 C3 7D 37     0820            JMP   DISPLA
3788              0830 *
3788              0840 *  ERROR MSG OUTPUT, STOP ON CR (0DH)
3788 7E           0850 ERROUT     MOV   A,M
3789 CD D8 38     0860            CALL  CHROUT
378C 7E           0870            MOV   A,M
378D FE 0D        0880            CPI   0DH
378F C8           0890            RZ
3790 23           0900            INX   H
3791 C3 88 37     0910            JMP   ERROUT
3794              0920 *
3794 0C           0930 MSG1       DB    0CH      * FIRST CLEAR THE SCREEN
3795 53 59 4E     0940            DT    'SYNTHESIS BY RULE'
3798 54 48 45
379B 53 49 53
379E 20 42 59
37A1 20 52 55
37A4 4C 45
37A6 0D           0950 MSG2       DB    0DH
37A7 45 4E 54     0960            DT    'ENTER TEXT:'
37AA 45 52 20
37AD 54 45 58
37B0 54 3A
37B2 0D           0970            DB    0DH
37B3 04           0980            DB    4
37B4              0990 *
37B4              1000 BUFF       DS    INBFLN   * PHONEME STRING INPUT BUFFER
3800              1010 *
3800              1020 *  END OF CSRMON KEYBOARD INPUT HANDLER
3800              1030 *
3800              1040 **********
3800              1050 *
3800              1060 *  DIAGNOSTIC DUMP ROUTINES FOR INFO & DEBUGGING
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

3800            1070 *
3800            1080            ORG   CSRMON+100H
3800            1090 *
3800            1100 *  DISPLAY CURRENT MATRIX CONTENTS
3800            1110 *  (CALLED BY INSTR INSERTED IN CSR1 CODE)
3800 21 EF 38   1120 MATDIS     LXI   H,MDTX
3803 CD 7D 37   1130            CALL  DISPLA   * DISPLAY "FEATURE MATRIX"
3806 2A 02 35   1140            LHLD  NEGEND
3809 11 06 35   1150            LXI   D,MATRIX+2
380C 19         1160            DAD   D
380D 7D         1170            MOV   A,L
380E 2F         1180            CMA
380F 4F         1190            MOV   C,A
3810 06 14      1200            MVI   B,20     * NUMBER OF COLS TO DISPLAY
3812 B8         1210            CMP   B
3813 DA 17 38   1220            JC    $+4
3816 48         1230            MOV   C,B
3817 C5         1240            PUSH  B
3818 21 05 35   1250            LXI   H,MATRIX+1
381B 23         1260 DL1        INX   H
381C CD 9D 38   1270            CALL  CODOUT
381F 0D         1280            DCR   C
3820 C2 1B 38   1290            JNZ   DL1
3823 CD D6 38   1300            CALL  CROUT
3826 C1         1310            POP   B
3827 06 04      1320            MVI   B,4
3829 21 05 35   1330            LXI   H,MATRIX+1
382C C5         1340 DL2        PUSH  B
382D 11 5F 00   1350            LXI   D,MATLEN
3830 19         1360            DAD   D
3831 E5         1370            PUSH  H
3832 23         1380 DL3        INX   H
3833 7E         1390            MOV   A,M
3834 CD 8D 38   1400            CALL  BYTE
3837 CD D1 38   1410            CALL  BLANK
383A 0D         1420            DCR   C
383B C2 32 38   1430            JNZ   DL3
383E CD D6 38   1440            CALL  CROUT
3841 E1         1450            POP   H
3842 C1         1460            POP   B
3843 05         1470            DCR   B
3844 C2 2C 38   1480            JNZ   DL2
3847 00         1490            NOP   *        * 'CALL CHRIN' TO PAUSE HERE
3848 00         1500            NOP
3849 00         1510            NOP
384A C9         1520            RET
384B            1530 *
384B            1540 *  BUFDIS
384B            1550 *  DUMP THE CURRENT BUFFER CONTENTS
384B            1560 *  (CALLED BY CTRL B DURING INPUT)
384B 2A 06 20   1570 BUFDIS     LHLD  BUFADR
384E 11 0B 00   1580            LXI   D,11
3851 19         1590            DAD   D
3852 22 DF 36   1600            SHLD  BUFPTR
3855 21 05 35   1610            LXI   H,MATRIX+1
3858 7E         1620 PHLOOP     MOV   A,M
3859 FE 04      1630            CPI   4
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

385B CA 53 37    1640             JZ    CUE1    * GO BACK TO INPUT LOOP
385E E5          1650             PUSH  H
385F 11 7C 01    1660             LXI   D,MATLEN*4
3862 EB          1670             XCHG
3863 19          1680             DAD   D
3864 7E          1690             MOV   A,M
3865 47          1700             MOV   B,A
3866 B7          1710             ORA   A
3867 CA 98 38    1720             JZ    ENDLP
386A EB          1730             XCHG
386B CD 9D 38    1740             CALL  CODOUT
386E 2A DF 36    1750             LHLD  BUFPTR
3871 C3 7D 38    1760             JMP   PHLP3
3874 CD D1 38    1770 PHLP2       CALL  BLANK
3877 CD D1 38    1780             CALL  BLANK
387A CD D1 38    1790             CALL  BLANK
387D 0E 09       1800 PHLP3       MVI   C,9
387F CD D1 38    1810 FRLOOP      CALL  BLANK
3882 7E          1820             MOV   A,M
3883 CD BD 38    1830             CALL  BYTE
3886 23          1840             INX   H
3887 0D          1850             DCR   C
3888 C2 7F 38    1860             JNZ   FRLOOP
388B CD D6 38    1870             CALL  CROUT
388E 05          1880             DCR   B
388F C2 74 38    1890             JNZ   PHLP2
3892 22 DF 36    1900             SHLD  BUFPTR
3895 00          1910             NOP
3896 00          1920             NOP
3897 00          1930             NOP
3898 E1          1940 ENDLP       POP   H
3899 23          1950             INX   H
389A C3 58 38    1960             JMP   PHLOOP
389D             1970 *
389D             1980 *  OUTPUT PHONEME CODE OF CURRENT MATRIX COLUMN
389D 7E          1990 CODOUT      MOV   A,M
389E 87          2000             ADD   A
389F EB          2010             XCHG
38A0 2A 0A 20    2020             LHLD  PVTAB
38A3 85          2030             ADD   L
38A4 6F          2040             MOV   L,A
38A5 7C          2050             MOV   A,H
38A6 CE 00       2060             ACI   0
38A8 67          2070             MOV   H,A
38A9 7E          2080             MOV   A,M
38AA CD D8 38    2090             CALL  CHROUT
38AD 23          2100             INX   H
38AE 7E          2110             MOV   A,M
38AF B7          2120             ORA   A
38B0 C2 B5 38    2130             JNZ   $+5
38B3 3E 20       2140             MVI   A,' '
38B5 CD D8 38    2150             CALL  CHROUT
38B8 CD D1 38    2160             CALL  BLANK
38BB EB          2170             XCHG
38BC C9          2180             RET
38BD             2190 *
38BD             2200 *  THE FOLLOWING ROUTINES ARE USED ONLY BY
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

38BD              2210 *  LOCAL CALLS, NOT BY CSR1
38BD F5           2220 BYTE      PUSH  PSW      * OUTPUT (A) AS 2 HEX DIGITS
38BE 0F           2230           RRC
38BF 0F           2240           RRC
38C0 0F           2250           RRC
38C1 0F           2260           RRC
38C2 CD C6 38     2270           CALL  HEXO
38C5 F1           2280           POP   PSW
38C6 E6 0F        2290 HEXO      ANI   0FH      * MASK OFF UPPER HALF
38C8 C6 90        2300           ADI   90H
38CA 27           2310           DAA
38CB CE 40        2320           ACI   40H
38CD 27           2330           DAA
38CE C3 D8 38     2340           JMP   CHROUT   * OUTPUT HEX DIGIT & TAKE LAST RET
38D1              2350 *
38D1 3E 20        2360 BLANK     MVI   A,' '
38D3 C3 D8 38     2370           JMP   CHROUT   * OUTPUT A SPACE
38D6              2380 *
38D6 3E 0D        2390 CROUT     MVI   A,0DH    * OUTPUT CR,(LF)
38D8              2400 *
38D8              2410 *  CHAR OUTPUT (CALLED TO OUTPUT (A))
38D8              2420 *   REDEFINE AS NEEDED
38D8 CD DC 38     2430 CHROUT    CALL  TTYOUT   * REDEFINE AS NEEDED
38DB C9           2440           RET
38DC              2450 *
38DC              2460 *  TTY OUTPUT HANDLER
38DC F5           2470 TTYOUT    PUSH  PSW
38DD DB 00        2480           IN    0
38DF E6 01        2490           ANI   1
38E1 CA DD 38     2500           JZ    $-4
38E4 F1           2510           POP   PSW
38E5 D3 01        2520           OUT   1
38E7 FE 0D        2530           CPI   0DH
38E9 C0           2540           RNZ
38EA 3E 0A        2550           MVI   A,0AH    * LAST CHAR WAS CR, ...
38EC C3 DC 38     2560           JMP   TTYOUT   * ADD A LINE FEED
38EF              2570 *
38EF              2580 *
38EF 0D           2590 MDTX      DB    0DH
38F0 46 45 41     2600           DT    'FEATURE MATRIX'
38F3 54 55 52
38F6 45 20 4D
38F9 41 54 52
38FC 49 58
38FE 0D           2610           DB    0DH
38FF 04           2620           DB    4
3900              2630 *
3900              2640 **********
3900              2650 *
3900              2660 *  A PORTION OF THE CSR1 JUMP TABLE IS DEFINED
3900              2670 *  TO ALLOW ACCESS TO MISC. CSR1 ADDRESSES
3900              2680 *
3900              2690           ORG   2000H
2000              2700 *
2000              2710 CSR1      DS    3
2003              2720 PLAY      DS    3
2006              2730 BUFADR    DS    2
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2008            2740 BUFEND     DS    2
200A            2750 PVTAB      DS    2
200C            2760 *
200C            2770 *  OTHER CSR1 LOCATIONS DEPENDENT ON LOC OF COMRAM
200C            2780 COMRAM     EQU   3500H
200C            2790 NEGEND     EQU   COMRAM+2
200C            2800 MATRIX     EQU   COMRAM+4
200C            2810 MATLEN     EQU   95
200C            2820 BUFPTR     EQU   MATLEN*5+MATRIX
200C            2830 *
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2000            0010 *  PARSE
2000            0020 *
2000            0030 *  SECTION 1 OF THE CSR1 SYNTHESIS BY RULE SYSTEM
2000            0040 *
2000            0050 *  LLOYD RICE,  COMPUTALKER CONSULTANTS
2000            0060 *  VERSION 1.07   MAY 30, 1977
2000            0070 *
2000            0080 *  THE ENTIRE CSR1 SOFTWARE SYSTEM IS PROVIDED
2000            0090 *  BY COMPUTALKER CONSULTANTS WITH THE UNDERSTANDING
2000            0100 *  THAT IT MAY BE REPRODUCED FOR NON-COMMERCIAL
2000            0110 *  PURPOSES, PROVIDED THAT THE SOURCE IS QUOTED.
2000            0120 *  OTHERWISE, ALL COPYRIGHTS ARE RETAINED.
2000            0130 *      (C)  1977,  COMPUTALKER CONSULTANTS
2000            0140 *
2000            0150 **********
2000            0160 *
2000            0170 *  ASSEMBLE ALL SECTIONS TO BEGIN AT THE SAME
2000            0180 *  STARTING ADDRESS.  THIS WILL BE THE ADDRESS
2000            0190 *  AT WHICH TO CALL THE CSR1 SYSTEM
2000            0200 *
2000            0210 **********
2000            0220 *
2000            0230 *  COMMON (JUMP) ADDRESS REFERENCE TABLE
2000            0240 *  THIS TABLE ALLOWS REASSEMBLING ANY SECTION
2000            0250 *  WITHOUT CHANGING REFERENCES IN OTHER SECTIONS
2000            0260 *
2000            0270 *  ANY SECTION MAY BE MOVED BY CHANGING THE ORG
2000            0280 *  AT SECTAD (SECTION 1 IS SLIGHTLY DIFFERENT).
2000            0290 *  ALL REFERENCES WILL BE HANDLED CORRECTLY.
2000            0300 *  THE COMMON RAM WORKSPACE DOES NOT SHARE THIS
2000            0310 *  NICE PROPERTY.  IT MUST BE DEFINED THE SAME
2000            0320 *  IN ALL SECTIONS.
2000            0330 *
2000            0340 **********
2000            0350 *
2000            0360 *  THE PARAMETER BUFFER IS DEFINED BY CONSTANTS IN
2000            0370 *  LOCATIONS BUFADR AND BUFEND.  BUFADR CONTAINS THE
2000            0380 *  ADDRESS OF THE 1ST BYTE OF THE FRAME COUNT, AND
2000            0390 *  BUFEND CONTAINS THE LAST ADDRESS AVAILABLE AS
2000            0400 *  BUFFER SPACE.
2000            0410 *  THESE LOCATIONS ARE DEFINED ONLY IN SECT1 SOURCE
2000            0420 *
2000            0430 **********
2000            0440 *
2000            0450 *  COMMON JUMP ADDRESS TABLE
2000            0460 *
2000            0470 COMJMP     EQU   $
2000            0480 *
2000 C3 3A 20   0490            JMP   CSR1
2003            0500 PLAY       DS    3
2006 00 39      0510 BUFADR     DW    COMJMP+1900H * 1ST BUFFER LOC AVAIL
2008 FF 5F      0520 BUFEND     DW    COMJMP+3FFFH * LAST LOC AVAILABLE
200A C5 22      0530            DW    PVTAB
200C C3 AC 22   0540            JMP   MATPAK
200F C3 9A 22   0550            JMP   MATERR
2012            0560 RULES      DS    3
2015            0570 SETDUR     DS    3
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ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2018            0580 RULES3     DS    3
201B            0590 GENFO      DS    3
201E            0600 CLRBUF     DS    3
2021            0610 GENPRM     DS    3
2024            0620 DUMMY      DS    22
203A            0630 *
203A            0640 SECTAD     EQU   $
203A            0650 *
203A            0660 **********
203A            0670 *
203A            0680 *  COMRAM ORIGEN DEFINITION
203A            0690 *
203A            0700            ORG   COMJMP+1500H
3500            0710 COMRAM     EQU   $
3500            0720 *
3500            0730 *  CSR1 SYSTEM RAM SPACE DEFINITION
3500            0740 *
3500            0750 MATPTR     DS    2
3502            0760 NEGEND     DS    2
3504            0770 MATRIX     EQU   $
3504            0780 MATLEN     EQU   95
3504            0790 PHCODE     DS    MATLEN
3563            0800 FEATA      DS    MATLEN
35C2            0810 FEATB      DS    MATLEN
3621            0820 STRES      DS    MATLEN
3680            0830 DUR        DS    MATLEN
36DF            0840 MATEND     EQU   $
36DF            0850 *
36DF            0860 *  PARSE (LOCAL) RAM WORKSPACE
36DF            0870 *
36DF            0880 CHAR       DS    1
36E0            0890 PHON       DS    2
36E2            0900 NUM        DS    1
36E3            0910 INPTR      DS    2
36E5            0920 *
36E5            0930 **********
36E5            0940 *
36E5            0950 *  CSR1 SYSTEM MAIN ROUTINE
36E5            0960 *
36E5            0970            ORG   SECTAD
203A            0980 *
203A            0990 *  DEFINE PHONEME CODES FOR PARSE
203A            1000 *
203A            1010 CPAUSE     EQU   2
203A            1020 CTERM      EQU   4
203A            1030 CAX        EQU   15
203A            1040 CEL        EQU   29
203A            1050 CEM        EQU   30
203A            1060 CEN        EQU   31
203A            1070 CL         EQU   33
203A            1080 CM         EQU   36
203A            1090 CN         EQU   37
203A            1100 CT         EQU   40
203A            1110 CD         EQU   44
203A            1120 CSH        EQU   51
203A            1130 CZH        EQU   55
203A            1140 CCH        EQU   56
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                                                             PAGE 03

ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

203A            1150 CJH        EQU   57
203A            1160 *
203A            1170 *  DEFINE FEATURE LABELS
203A            1180 *
203A            1190 VOWEL      EQU   80H
203A            1200 CONS       EQU   40H
203A            1210 FRONT      EQU   20H
203A            1220 DIPHTH     EQU   10H
203A            1230 WDBND      EQU   4
203A            1240 PHBND      EQU   2
203A            1250 IGNORE     EQU   1
203A            1260 STOP       EQU   80H
203A            1270 VOICE      EQU   40H
203A            1280 PLOS       EQU   20H
203A            1290 PLOSA      EQU   10H
203A            1300 PRIC       EQU   8
203A            1310 LIQUID     EQU   4
203A            1320 NASAL      EQU   2
203A            1330 DENTAL     EQU   1
203A            1340 *
203A            1350 *  DEFINE INPUT STRING TERMINATOR
203A            1360 *
203A            1370 TERM      - EQU   0DH
203A            1380 *
203A            1390 **********
203A            1400 *
203A            1410 *  CSR1 MAIN LOOP
203A            1420 *
203A C5         1430 CSR1       PUSH  B         * SAVE BC,DE
203B D5         1440            PUSH  D
203C CD 63 20   1450            CALL  PARSE     * PARSE INPUT & SET UP MATRIX
203F C2 60 20   1460            JNZ   CSERR     * RETURN IF ERROR
2042 00         1470            NOP
2043 00         1480            NOP
2044 00         1490            NOP
2045 CD 12 20   1500            CALL  RULES     * APPLY RULES TO MATRIX
2048 C2 60 20   1510            JNZ   CSERR     * RETURN IF ERROR
204B 00         1520            NOP
204C 00         1530            NOP
204D 00         1540            NOP
204E CD 1B 20   1550            CALL  GENF0     * GENERATE F0 PARAMETER
2051 C2 60 20   1560            JNZ   CSERR     * RETURN IF ERROR
2054 00         1570            NOP
2055 00         1580            NOP
2056 00         1590            NOP
2057 CD 21 20   1600            CALL  GENPRM    * GENERATE OTHER PARAMETERS
205A 00         1610            NOP
205B 00         1620            NOP
205C 00         1630            NOP
205D CD 03 20   1640            CALL  PLAY      * PLAYBACK TO SYNTHESIZER
2060 D1         1650 CSERR      POP   D
2061 C1         1660            POP   B
2062 C9         1670            RET
2063            1680 *
2063            1690 *
2063            1700 **********
2063            1710 *
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2063            1720 *  PARSE CODE
2063            1730 *
2063            1740 **********
2063            1750 *
2063 22 E3 36   1760 PARSE      SHLD  INPTR      * SAVE INPUT TEXT POINTER
2066 21 04 35   1770            LXI   H,MATRIX
2069 22 00 35   1780            SHLD  MATPTR     * INITIALIZE PHONEME MATRIX
206C AF         1790            XRA   A
206D 32 E2 36   1800            STA   NUM
2070 3E 04      1810            MVI   A,CTERM    * FRONT MATRIX TERMINATOR
2072 CD 7A 22   1820            CALL  MATSET     * NO ERROR TEST NEEDED
2075 3E 02      1830            MVI   A,CPAUSE
2077 CD 7A 22   1840            CALL  MATSET     * SET UP INITIAL PAUSE
207A CD BD 21   1850 PARSA      CALL  GET
207D FE 0D      1860 PARSB      CPI   TERM       * END OF INPUT?
207F 3E 00      1870            MVI   A,0        * DON'T WIPE THE Z FLAG
2081 32 E2 36   1880            STA   NUM
2084 CA 3F 21   1890            JZ    FINUP      * END, CLOSE THE MATRIX
2087 67         1900            MOV   H,A
2088 6F         1910            MOV   L,A
2089 22 E0 36   1920            SHLD  PHON       * CLEAR PHON,
208C 4F         1930            MOV   C,A        * & C FOR HH COUNTER
208D 7A         1940            MOV   A,D        * GET PARSER FLAGS INTO A
208E 17         1950            RAL
208F DA A6 20   1960            JC    VOWELA     * VOWEL CLASS A
2092 17         1970            RAL
2093 DA CD 20   1980            JC    CONSB      * CONSONANT CLASS B
2096 17         1990            RAL
2097 DA 18 21   2000            JC    CONSA      * CONSONANT CLASS A
209A 17         2010            RAL
209B DA 33 21   2020            JC    COMMT      * COMMENT DELIMITER
209E E6 C0      2030            ANI   0C0H
20A0 C2 20 21   2040            JNZ   PLKPA      * SINGLE CHAR SYMBOL
20A3 C3 5F 21   2050            JMP   ERROR      * BAD INPUT
20A6            2060 *
20A6 CD B1 21   2070 VOWELA     CALL  PUSHP      * PUSH VOWEL CHAR A, GET CHAR B
20A9 7A         2080            MOV   A,D
20AA 1F         2090            RAR
20AB D2 5F 21   2100            JNC   ERROR      * IF NOT VOWEL B, IT'S AN ERROR
20AE CD B1 21   2110            CALL  PUSHP      * PUSH CHAR B, GET NEXT
20B1 7A         2120 GETDIG     MOV   A,D        * SEE IF VOWEL IS FOLLOWED BY INT
20B2 1F         2130            RAR
20B3 1F         2140            RAR
20B4 D2 DA 20   2150            JNC   LKPNG      * NOT A DIGIT, LOOKUP THE VOWEL
20B7 3A DF 36   2160            LDA   CHAR       * ACCUMULATE STRESS VALUE IN C
20BA D6 30      2170            SUI   '0'
20BC 47         2180            MOV   B,A        * SAVE NEW DIGIT IN B
20BD 79         2190            MOV   A,C
20BE 87         2200            ADD   A
20BF 87         2210            ADD   A
20C0 81         2220            ADD   C
20C1 87         2230            ADD   A          * 10 TIMES PREVIOUS VALUE
20C2 80         2240            ADD   B          * PLUS NEW DIGIT
20C3 4F         2250            MOV   C,A        * INTO C
20C4 32 E2 36   2260            STA   NUM        * AND INTO NUM
20C7 CD BD 21   2270            CALL  GET
20CA C3 B1 20   2280            JMP   GETDIG     * & SEE IF THERE'S ANOTHER DIGIT
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

20CD            2290 *
20CD CD B1 21   2300 CONSB       CALL  PUSHP       * PUSH CONS CHAR, GET NEXT
20D0 FE 48      2310             CPI   'H'         * IS IT FOLLOWED BY AN "H"?
20D2 CA F0 20   2320             JZ    GETH        * YES
20D5 FE 58      2330             CPI   'X'         * IS IT FOLLOWED BY AN 'X'
20D7 CA 20 21   2340             JZ    PLKPA       * YES, PUSH & LOOK IT UP
20DA CD 0B 22   2350 LKPNG       CALL  LOOKUP      * NO, LOOKUP, DON'T GET AGAIN
20DD C0         2360             RNZ   *           * RETURN IF ERROR
20DE 3A DF 36   2370 PARSBG      LDA   CHAR
20E1 CD CA 21   2380             CALL  GETFLG      * GET CHAR FLAGS INTO D AGAIN
20E4 C3 7D 20   2390             JMP   PARSB
20E7            2400 *
20E7 0C         2410 INCRH       INR   C           * INCREMENT THE "H" COUNTER
20E8 CD BD 21   2420             CALL  GET
20EB FE 48      2430             CPI   'H'
20ED C2 03 21   2440             JNZ   LKPH        * CHAR IS NOT H, LOOKUP LAST HH
20F0 CD BD 21   2450 GETH        CALL  GET
20F3 FE 48      2460             CPI   'H'
20F5 CA E7 20   2470             JZ    INCRH       * WE HAVE ANOTHER 'H'
20F8 3A E1 36   2480             LDA   PHON+1      * END OF THE STRING OF 'H'S
20FB 32 E0 36   2490             STA   PHON
20FE 3E 48      2500             MVI   A,'H'
2100 32 E1 36   2510             STA   PHON+1      * PUSH AN 'H' INTO PHON
2103 CD 0B 22   2520 LKPH        CALL  LOOKUP      * LOOK IT UP
2106 C0         2530             RNZ
2107 79         2540             MOV   A,C
2108 B7         2550             ORA   A
2109 CA DE 20   2560             JZ    PARSBG      * ALL HH'S DONE, CHAR IS NEXT
210C 3E 48      2570             MVI   A,'H'
210E 32 E0 36   2580             STA   PHON
2111 32 E1 36   2590             STA   PHON+1      * FORCE PHON TO 'HH'
2114 0D         2600             DCR   C
2115 C3 03 21   2610             JMP   LKPH        * AND LOOK IT UP
2118            2620 *
2118 CD B1 21   2630 CONSA       CALL  PUSHP       * PUSH CONS CHAR, GET NEXT
211B FE 48      2640             CPI   'H'
211D C2 5F 21   2650             JNZ   ERROR       * CLASS A CONS MUST HAVE 'H' NEXT
2120 3A E1 36   2660 PLKPA       LDA   PHON+1      * PUSH IT INTO PHON
2123 32 E0 36   2670             STA   PHON
2126 3A DF 36   2680             LDA   CHAR
2129 32 E1 36   2690             STA   PHON+1
212C CD 0B 22   2700             CALL  LOOKUP      * LOOK IT UP
212F C0         2710             RNZ
2130 C3 7A 20   2720             JMP   PARSA       * GET NEXT INPUT
2133            2730 *
2133 CD BD 21   2740 COMMT       CALL  GET         * GET ANOTHER CHAR
2136 7A         2750             MOV   A,D
2137 E6 10      2760             ANI   10H
2139 CA 33 21   2770             JZ    COMMT       * IGNORE ALL UNTIL NEXT CMMT DELI
213C C3 7A 20   2780             JMP   PARSA
213F            2790 *
213F AF         2800 FINUP       XRA   A
2140 32 E2 36   2810             STA   NUM
2143 3E 02      2820             MVI   A,CPAUSE
2145 CD 7A 22   2830             CALL  MATSET      * PUT FINAL PAUSE IN MATRIX
2148 C0         2840             RNZ
2149 3E 04      2850             MVI   A,CTERM
```

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ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

214B CD 7A 22    2860            CALL  MATSET    * TERMINATE MATRIX
214E C0          2870            RNZ
214F 2A 00 35    2880            LHLD  MATPTR
2152 7C          2890            MOV   A,H
2153 2F          2900            CMA
2154 67          2910            MOV   H,A
2155 7D          2920            MOV   A,L
2156 2F          2930            CMA
2157 6F          2940            MOV   L,A
2158 23          2950            INX   H
2159 23          2960            INX   H
215A 22 02 35    2970            SHLD  NEGEND   * -ADDRESS OF TERM PHON
215D AF          2980            XRA   A
215E C9          2990            RET
215F             3000 *
215F             3010 *  SYNTAX ERROR MESSAGE RETURN
215F             3020 *
215F 21 80 36    3030 ERROR      LXI   H,DUR     * USE DURATION ARRAY FOR MSG
2162 11 9F 21    3040            LXI   D,ERTX1
2165 CD 98 21    3050            CALL  MOVCH     * MOVE 1ST PART OF MSG
2168 C2 65 21    3060            JNZ   $-3
216B 36 0D       3070            MVI   M,0DH     * TERMINATE IT
216D 11 E1 36    3080            LXI   D,PHON+1 * SEE IF ANYTHING IN PHON
2170 1A          3090            LDAX  D
2171 47          3100            MOV   B,A
2172 1B          3110            DCX   D
2173 1A          3120            LDAX  D
2174 B0          3130            ORA   B
2175 CA 92 21    3140            JZ    NZRET     * NO, SET NON-0 & RETURN
2178 11 AB 21    3150            LXI   D,ERTX2   * YES, ADD MORE TO MSG
217B CD 98 21    3160            CALL  MOVCH
217E C2 7B 21    3170            JNZ   $-3
2181 11 E0 36    3180            LXI   D,PHON
2184 CD 98 21    3190            CALL  MOVCH     * MOVE NON-0 PARTS OF PHON & CHA
2187 CD 98 21    3200            CALL  MOVCH
218A CD 98 21    3210            CALL  MOVCH
218D 36 22       3220            MVI   M,'"'
218F 23          3230            INX   H
2190 36 0D       3240            MVI   M,0DH     * TERMINATE THE MSG
2192 21 80 36    3250 NZRET      LXI   H,DUR
2195 F6 FF       3260            ORI   255
2197 C9          3270            RET
2198             3280 *
2198 1A          3290 MOVCH      LDAX  D
2199 13          3300            INX   D
219A B7          3310            ORA   A
219B C8          3320            RZ
219C 77          3330            MOV   M,A
219D 23          3340            INX   H
219E C9          3350            RET
219F             3360 *
219F 49 4E 50    3370 ERTX1      DT    'INPUT ERROR'
21A2 55 54 20
21A5 45 52 52
21A8 4F 52
21AA 00          3380            DB    0
21AB 20 41 54    3390 ERTX2      DT    ' AT "'
```

```
ADDR B1 B2 B3-E LINE  LABEL      OPCD  OPERAND

21AE 20 22
21B0 00          3400             DB    0
21B1             3410 *
21B1             3420 **********
21B1             3430 *
21B1             3440 *  PARSE SUBROUTINES
21B1             3450 *
21B1 3A E1 36    3460 PUSHP       LDA   PHON+1
21B4 32 E0 36    3470             STA   PHON
21B7 3A DF 36    3480             LDA   CHAR
21BA 32 E1 36    3490             STA   PHON+1
21BD             3500 *
21BD 2A E3 36    3510 GET         LHLD  INPTR
21C0 7E          3520             MOV   A,M       * GET NEXT INPUT CHAR
21C1 E6 7F       3530             ANI   7FH
21C3 32 DF 36    3540             STA   CHAR      * SAVE IT
21C6 23          3550             INX   H         * AND BUMP INPUT POINTER
21C7 22 E3 36    3560             SHLD  INPTR
21CA C5          3570 GETFLG      PUSH  B
21CB 4F          3580             MOV   C,A       * KEEP CHAR IN C FOR NOW
21CC E6 1F       3590             ANI   1FH       * KEEP 5 LS BITS
21CE 5F          3600             MOV   E,A
21CF 21 E7 21    3610             LXI   H,PARFLG  * ADDR OF FLAGS TABLE
21D2 16 00       3620             MVI   D,0
21D4 19          3630             DAD   D
21D5 46          3640             MOV   B,M       * GET FLAGS WORD IN B
21D6 79          3650             MOV   A,C       * GET WHOLE CHAR BACK
21D7 07          3660             RLC
21D8 07          3670             RLC
21D9 07          3680             RLC
21DA E6 03       3690             ANI   3         * KEEP CHAR BITS 5,6 IN A 0,1
21DC 5F          3700             MOV   E,A       * OFFSET TO MASK TABLE
21DD 21 07 22    3710             LXI   H,CHMASK
21E0 19          3720             DAD   D
21E1 7E          3730             MOV   A,M       * GET MASK BITS IN A
21E2 A0          3740             ANA   B
21E3 57          3750             MOV   D,A       * RETURN FLAGS IN D
21E4 79          3760             MOV   A,C       * RETURN CHAR IN A
21E5 C1          3770             POP   B
21E6 C9          3780             RET
21E7             3790 *
21E7             3800 *  PARSER FLAGS TABLE
21E7             3810 *
21E7 04          3820 PARFLG      DB    04H   * @,SPACE
21E8 81          3830             DB    81H   * A,!
21E9 08          3840             DB    08H   * B,"
21EA 20          3850             DB    20H   * C,#
21EB 40          3860             DB    40H   * D,$
21EC 81          3870             DB    81H   * E,%
21ED 08          3880             DB    08H   * F,&
21EE 40          3890             DB    40H   * G,'
21EF 21          3900             DB    21H   * H,(
21F0 81          3910             DB    81H   * I,)
21F1 30          3920             DB    30H   * J,*
21F2 40          3930             DB    40H   * K,+
21F3 45          3940             DB    45H   * L,,
21F4 0D          3950             DB    0DH   * M,-
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

21F5 45            3960              DB    45H   * N,.
21F6 85            3970              DB    85H   * O,/
21F7 0A            3980              DB    0AH   * P,0
21F8 0A            3990              DB    0AH   * Q,1
21F9 43            4000              DB    43H   * R,2
21FA 42            4010              DB    42H   * S,3
21FB 42            4020              DB    42H   * T,4
21FC 83            4030              DB    83H   * U,5
21FD 0A            4040              DB    0AH   * V,6
21FE 43            4050              DB    43H   * W,7
21FF 03            4060              DB    03H   * X,8
2200 43            4070              DB    43H   * Y,9
2201 44            4080              DB    44H   * Z,:
2202 04            4090              DB    04H   * [,;
2203 00            4100              DB    0     * BACK SLASH,<
2204 00            4110              DB    0     * ],=
2205 00            4120              DB    0     * UP ARROW,>
2206 04            4130              DB    04H   * LEFT ARROW,
2207               4140 *
2207               4150 *  PARSER FLAGS BIT MASKS
2207               4160 *
2207 00            4170 CHMASK       DB    0      * CONTROL CHAR, CLEAR FLAGS
2208 16            4180              DB    16H    * PUNCTUATION, USE BITS 4,2,1
2209 E9            4190              DB    0E9H   * UPPER CASE, USE BITS 7,6,5,3,0
220A 00            4200              DB    0      * LOWER CASE, CLEAR FLAGS
220B               4210 *
220B               4220 *
220B               4230 *  LOOKUP SUBROUTINE
220B               4240 *
220B C5            4250 LOOKUP       PUSH  B
220C 2A E0 26      4260              LHLD  PHON       * 2ND HALF OF PHON INTO H
220F 7D            4270              MOV   A,L        * & 1ST HALF IN A & L
2210 B7            4280              ORA   A
2211 CA 16 22      4290              JZ    NCHP       * IF 1ST 1/2 =0, MAKE IT THE 2ND
2214 6C            4300              MOV   L.H        * INTERCHANGE H & L
2215 67            4310              MOV   H,A
2216 EB            4320 NCBP         XCHG  *          * NON 0 PART IN D, 2ND 1/2 IN E
2217 0E 40         4330              MVI   C.64
2219 21 C5 22      4340              LXI   H,PVTAB
221C 7A            4350 CHECK        MOV   A,D        * SEARCH VALID. TABLE FOR (PHON)
221D BE            4360              CMP   M
221E 23            4370              INX   H
221F C2 27 22      4380              JNZ   P1BAD
2222 7E            4390              MOV   A,E        * 1ST 1/2 FOUND. TRY 2ND 1/2
2223 BE            4400              CMP   M
2224 CA 30 22      4410              JZ    MATCH
2227 23            4420 P1BAD        INX   H          * NOT THIS ONE
2228 0D            4430              DCR   C
2229 C2 1C 22      4440              JNZ   CHECK
222C C1            4450              POP   B
222D C3 5F 21      4460              JMP   ERROR      * (PHON) NOT IN VALID. TABLE
2230               4470 *
2230 3E 3A         4480 MATCH        MVI   A,-PVTAB-1%256   * (-PVTAB-1)MOD 256
2232 85            4490              ADD   L
2233 0F            4500              RRC
2234 FE 1D         4510              CPI   CEL        * CHECK NOW FOR DUMMY CODES
2236 CA 50 22      4520              JZ    INSAXL     * EL BECOMES AX,L
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2239 FE 1E       4530            CPI   CEM
223B CA 55 22    4540            JZ    INSAXM    * EM BECOMES AX,M
223E FE 1F       4550            CPI   CEN
2240 CA 5A 22    4560            JZ    INSAXN    * EN BECOMES AX,N
2243 FE 38       4570            CPI   CCH
2245 CA 61 22    4580            JZ    INSTSH    * CH BECOMES T,SH
2248 FE 39       4590            CPI   CJH
224A CA 68 22    4600            JZ    INSDZH    * JH BECOMES D,ZH
224D C3 75 22    4610            JMP   PUTMAT    * ELSE PUT IT IN THE MATRIX
2250             4620 *
2250 06 21       4630 INSAXL     MVI   B,CL
2252 C3 5C 22    4640            JMP   INS1
2255 06 24       4650 INSAXM     MVI   B,CM
2257 C3 5C 22    4660            JMP   INS1
225A 06 25       4670 INSAXN     MVI   B,CN
225C 3E 0F       4680 INS1       MVI   A,CAX
225E C3 6C 22    4690            JMP   INS2
2261 3E 28       4700 INSTSH     MVI   A,CT
2263 06 33       4710            MVI   B,CSH
2265 C3 6C 22    4720            JMP   INS2
2268 3E 2C       4730 INSDZH     MVI   A,CD
226A 06 37       4740            MVI   B,CZH
226C CD 7A 22    4750 INS2       CALL  MATSET    * PUT 1ST PHON IN MATRIX
226F 3E 00       4760            MVI   A,0
2271 32 E2 36    4770            STA   NUM       * CLEAR STRESS VALUE FOR 2ND PHO
2274 78          4780            MOV   A,B
2275 CD 7A 22    4790 PUTMAT     CALL  MATSET    * AND PUT IT IN MATRIX
2278 C1          4800            POP   B
2279 C9          4810            RET
227A             4820 *
227A             4830 *
227A 2A 00 35    4840 MATSET     LHLD  MATPTR    * TEST COLUMN POINTER
227D 11 9C CA    4850            LXI   D,-MATRIX-MATLEN-1
2280 19          4860            DAD   D
2281 DA 9A 22    4870            JC    MATERR    * MATRIX OVERFLOW
2284 C5          4880            PUSH  B         * SAVE B
2285 CD AC 22    4890            CALL  MATPAK    * PUT NEW CODE INTO MATRIX
2288 09          4900            DAD   B
2289 3A E2 36    4910            LDA   NUM
228C 77          4920            MOV   M,A       * GET STRESS VALUE FROM NUM
228D 09          4930            DAD   B
228E 36 00       4940            MVI   M,0       * DURATION VALUES
2290 C1          4950            POP   B         * RESTORE B
2291 2A 00 35    4960            LHLD  MATPTR
2294 23          4970            INX   H
2295 22 00 35    4980            SHLD  MATPTR    * BUMP THE COLUMN PTR
2298 AF          4990            XRA   A         * SET ZERO CONDITION
2299 C9          5000            RET
229A             5010 *
229A 21 A0 22    5020 MATERR     LXI   H,MERTX
229D F6 FF       5030            ORI   255
229F C9          5040            RET
22A0             5050 *
22A0 4D 41 54    5060 MERTX      DT    'MATRIX FULL'
22A3 52 49 58
22A6 20 46 55
22A9 4C 4C
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

22AB 0D            5070            DB    0DH
22AC               5080 *
22AC               5090 *
22AC               5100 *  MATPAK SUBROUTINE
22AC               5110 *
22AC 2A 00 35      5120 MATPAK     LHLD  MATPTR
22AF 77            5130            MOV   M,A       * PUT CODE IN ROW 1
22B0 EB            5140            XCHG
22B1 07            5150            RLC
22B2 4F            5160            MOV   C,A
22B3 06 00         5170            MVI   B,0       * CODE*2 INTO BC
22B5 21 3D 23      5180            LXI   H,FEATAB
22B8 09            5190            DAD   B
22B9 EB            5200            XCHG  *         * FEATURE ADDR IN DE
22BA 01 5F 00      5210            LXI   B,MATLEN
22BD 09            5220            DAD   B         * BUMP HL TO FEATA ROW
22BE 1A            5230            LDAX  D
22BF 77            5240            MOV   M,A       * MOVE 1ST FEATURE WORD T MATRIX
22C0 13            5250            INX   D
22C1 1A            5260            LDAX  D
22C2 09            5270            DAD   B
22C3 77            5280            MOV   M,A       * MOVE 2ND FEATURE WORD TO MATRIX
22C4 C9            5290            RET
22C5               5300 *
N 22C5             5310 *******
22C5               5320 *
22C5               5330 *  PHONEME VALIDATION TABLE
22C5               5340 *
22C5 20            5350 PVTAB      DB    ' '
22C6 00            5360            DB    0
22C7 2E            5370            DB    '.'
22C8 00            5380            DB    0
22C9 2C            5390            DB    ','
22CA 00            5400            DB    0
22CB 3F            5410            DB    '?'
22CC 00            5420            DB    0
22CD 23            5430            DB    '#'
22CE 00            5440            DB    0
22CF 49 59         5450            DT    'IY'
22D1 49 48         5460            DT    'IH'
22D3 45 48         5470            DT    'EH'
22D5 41 45         5480            DT    'AE'
22D7 41 41         5490            DT    'AA'
22D9 41 48         5500            DT    'AH'
22DB 41 4F         5510            DT    'AO'
22DD 4F 57         5520            DT    'OW'
22DF 55 48         5530            DT    'UH'
22E1 55 57         5540            DT    'UW'
22E3 41 58         5550            DT    'AX'
22E5 49 58         5560            DT    'IX'
22E7 45 52         5570            DT    'ER'
22E9 55 58         5580            DT    'UX'
22EB 4F 48         5590            DT    'OH'
22ED 41 57         5600            DT    'AW'
22EF 41 59         5610            DT    'AY'
22F1 4F 59         5620            DT    'OY'
22F3 45 59         5630            DT    'EY'
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

22F5 52 58      5640            DT    'RX'
22F7 4C 58      5650            DT    'LX'
22F9 57 58      5660            DT    'WX'
22FB 59 58      5670            DT    'YX'
22FD 57 48      5680            DT    'WH'
22FF 45 4C      5690            DT    'EL'
2301 45 4D      5700            DT    'EM'
2303 45 4E      5710            DT    'EN'
2305 52         5720            DB    'R'
2306 00         5730            DB    0
2307 4C         5740            DB    'L'
2308 00         5750            DB    0
2309 57         5760            DB    'W'
230A 00         5770            DB    0
230B 59         5780            DB    'Y'
230C 00         5790            DB    0
230D 4D         5800            DB    'M'
230E 00         5810            DB    0
230F 4E         5820            DB    'N'
2310 00         5830            DB    0
2311 4E 58      5840            DT    'NX'
2313 50         5850            DB    'P'
2314 00         5860            DB    0
2315 54         5870            DB    'T'
2316 00         5880            DB    0
2317 4B         5890            DB    'K'
2318 00         5900            DB    0
2319 4B 58      5910            DT    'KX'
231B 42         5920            DB    'B'
231C 00         5930            DB    0
231D 44         5940            DB    'D'
231E 00         5950            DB    0
231F 47         5960            DB    'G'
2320 00         5970            DB    0
2321 47 58      5980            DT    'GX'
2323 44 58      5990            DT    'DX'
2325 46         6000            DB    'F'
2326 00         6010            DB    0
2327 54 48      6020            DT    'TH'
2329 53         6030            DB    'S'
232A 00         6040            DB    0
232B 53 48      6050            DT    'SH'
232D 56         6060            DB    'V'
232E 00         6070            DB    0
232F 44 48      6080            DT    'DH'
2331 5A         6090            DB    'Z'
2332 00         6100            DB    0
2333 5A 48      6110            DT    'ZH'
2335 43 48      6120            DT    'CH'
2337 4A 48      6130            DT    'JH'
2339 48 48      6140            DT    'HH'
233B 51         6150            DB    'Q'
233C 00         6160            DB    0
233D            6170  *
233D            6180  *
233D            6190  *  FEATURE DEFINITION TABLE
233D            6200  *
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

233D 05          6210 FEATAB     DB    WDBND+IGNORE   * SPACE
233E 00          6220            DB    0
233F 03          6230            DB    PHBND+IGNORE   * PERIOD
2340 00          6240            DB    0
2341 02          6250            DB    PHBND    * COMMA
2342 00          6260            DB    0
2343 03          6270            DB    PHBND+IGNORE   * QUESTION
2344 00          6280            DB    0
2345 03          6290            DB    PHBND+IGNORE   * TERMINATOR
2346 00          6300            DB    0
2347 A0          6310            DB    VOWEL+FRONT    * IY
2348 40          6320            DB    VOICE
2349 A0          6330            DB    VOWEL+FRONT    * IH
234A 40          6340            DB    VOICE
234B A0          6350            DB    VOWEL+FRONT    * EH
234C 40          6360            DB    VOICE
234D A0          6370            DB    VOWEL+FRONT    * AE
234E 40          6380            DB    VOICE
234F A0          6390            DB    VOWEL+FRONT    * AA
2350 40          6400            DB    VOICE
2351 A0          6410            DB    VOWEL+FRONT    * AH
2352 40          6420            DB    VOICE
2353 80          6430            DB    VOWEL    * AO
2354 40          6440            DB    VOICE
2355 90          6450            DB    VOWEL+DIPHTH   * OW
2356 40          6460            DB    VOICE
2357 80          6470            DB    VOWEL          * UH
2358 40          6480            DB    VOICE
2359 90          6490            DB    VOWEL+DIPHTH   * UW
235A 40          6500            DB    VOICE
235B 80          6510            DB    VOWEL          * AX
235C 40          6520            DB    VOICE
235D 80          6530            DB    VOWEL          * IX
235E 40          6540            DB    VOICE
235F 80          6550            DB    VOWEL          * ER
2360 40          6560            DB    VOICE
2361 80          6570            DB    VOWEL          * UX
2362 40          6580            DB    VOICE
2363 80          6590            DB    VOWEL          * OH
2364 40          6600            DB    VOICE
2365 90          6610            DB    VOWEL+DIPHTH   * AW
2366 40          6620            DB    VOICE
2367 B0          6630            DB    VOWEL+FRONT+DIPHTH * AY
2368 40          6640            DB    VOICE
2369 B0          6650            DB    VOWEL+FRONT+DIPHTH * OY
236A 40          6660            DB    VOICE
236B B0          6670            DB    VOWEL+FRONT+DIPHTH * EY
236C 40          6680            DB    VOICE
236D 80          6690            DB    VOWEL          * RX
236E 40          6700            DB    VOICE
236F 80          6710            DB    VOWEL          * LX
2370 40          6720            DB    VOICE
2371 80          6730            DB    VOWEL          * WX
2372 40          6740            DB    VOICE
2373 80          6750            DB    VOWEL          * YX
2374 40          6760            DB    VOICE
2375 40          6770            DB    CONS           * WH
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2376 40          6780            DB    VOICE
2377 00          6790            DB    0      * EL
2378 00          6800            DB    0
2379 00          6810            DB    0      * EM
237A 00          6820            DB    0
237B 00          6830            DB    0      * EN
237C 00          6840            DB    0
237D 40          6850            DB    CONS             * R
237E 44          6860            DB    VOICE+LIQUID
237F 40          6870            DB    CONS             * L
2380 44          6880            DB    VOICE+LIQUID
2381 40          6890            DB    CONS             * W
2382 44          6900            DB    VOICE+LIQUID
2383 40          6910            DB    CONS             * Y
2384 40          6920            DB    VOICE
2385 40          6930            DB    CONS             * M
2386 C2          6940            DB    STOP+VOICE+NASAL
2387 40          6950            DB    CONS             * N
2388 C3          6960            DB    STOP+VOICE+NASAL+DENTAL
2389 40          6970            DB    CONS             * NX
238A C2          6980            DB    STOP+VOICE+NASAL
238B 40          6990            DB    CONS             * P
238C B0          7000            DB    STOP+PLOS+PLOSA
238D 40          7010            DB    CONS             * T
238E B1          7020            DB    STOP+PLOS+PLOSA+DENTAL
238F 40          7030            DB    CONS             * K
2390 B0          7040            DB    STOP+PLOS+PLOSA
2391 40          7050            DB    CONS             * KX
2392 B0          7060            DB    STOP+PLOS+PLOSA
2393 40          7070            DB    CONS             * B
2394 E0          7080            DB    STOP+PLOS+VOICE
2395 40          7090            DB    CONS             * D
2396 E1          7100            DB    STOP+PLOS+VOICE+DENTAL
2397 40          7110            DB    CONS             * G
2398 E0          7120            DB    STOP+PLOS+VOICE
2399 40          7130            DB    CONS             * GX
239A E0          7140            DB    STOP+PLOS+VOICE
239B 40          7150            DB    CONS             * DX
239C 81          7160            DB    STOP+DENTAL
239D 40          7170            DB    CONS             * F
239E 08          7180            DB    FRIC
239F 40          7190            DB    CONS             * TH
23A0 09          7200            DB    FRIC+DENTAL
23A1 40          7210            DB    CONS             * S
23A2 09          7220            DB    FRIC+DENTAL
23A3 40          7230            DB    CONS             * SH
23A4 08          7240            DB    FRIC
23A5 40          7250            DB    CONS             * V
23A6 48          7260            DB    FRIC+VOICE
23A7 40          7270            DB    CONS             * DH
23A8 49          7280            DB    FRIC+VOICE+DENTAL
23A9 40          7290            DB    CONS             * Z
23AA 49          7300            DB    FRIC+VOICE+DENTAL
23AB 40          7310            DB    CONS             * ZH
23AC 48          7320            DB    FRIC+VOICE
23AD 00          7330            DB    0         * CH
23AE 00          7340            DB    0
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

23AF 00          7350           DB    0          * JH
23B0 00          7360           DB    0
23B1 40          7370           DB    CONS       * HH
23B2 00          7380           DB    0
23B3 40          7390           DB    CONS       * Q
23B4 C0          7400           DB    STOP+VOICE
23B5             7410 *
23B5             7420 *  END OF SECT1
```

```
                                                                    PAGE 01

ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2000             0010 *  RULES, GROUPS 1 AND 2
2000             0020 *
2000             0030 *  SECTION 2 OF THE CSR1 SYNTHESIS BY RULE SYSTEM
2000             0040 *
2000             0050 *  LLOYD RICE,  COMPUTALKER CONSULTANTS
2000             0060 *  VERSION 1.07   MAY 30, 1977
2000             0070 *
2000             0080 **********
2000             0090 *
2000             0100 *  COMMON JUMP ADDRESS TABLE
2000             0110 *  THIS TABLE ALLOWS REASSEMBLING ANY SECTION
2000             0120 *  WITHOUT CHANGING REFERENCES IN OTHER SECTIONS
2000             0130 *
2000             0140 **********
2000             0150 *
2000             0160 COMJMP     EQU   $
2000             0170 *
2000             0180 CSR1       DS    3
2003             0190 PLAY       DS    3
2006             0200 BUFADR     DS    2
2008             0210 BUFEND     DS    2
200A             0220 PVTAB      DS    2
200C             0230 MATPAK     DS    3
200F             0240 MATERR     DS    3
2012 C3 C0 23    0250            JMP   RULES
2015             0260 SETDUR     DS    3
2018             0270 RULES3     DS    3
201B             0280 GENFO      DS    3
201E             0290 CLRBUF     DS    3
2021             0300 GENPRM     DS    3
2024             0310 DUMMY      DS    22
203A             0320 *
203A             0330 **********
203A             0340 *
203A             0350 *  COMRAM ORIGEN DEFINITION
203A             0360 *
203A             0370            ORG   COMJMP+1500H
3500             0380 COMRAM     EQU   $
3500             0390 *
3500             0400 *  CSR1 SYSTEM RAM SPACE DEFINITION
3500             0410 *
3500             0420 MATPTR     DS    2
3502             0430 NEGEND     DS    2
3504             0440 MATRIX     EQU   $
3504             0450 MATLEN     EQU   95
3504             0460 PHCODE     DS    MATLEN
3563             0470 FEATA      DS    MATLEN
35C2             0480 FEATB      DS    MATLEN
3621             0490 STRES      DS    MATLEN
3680             0500 DUR        DS    MATLEN
36DF             0510 MATEND     EQU   $
36DF             0520 *
36DF             0530 *  RULES (LOCAL) RAM WORKSPACE
36DF             0540 *
36DF             0550 MOVAD      DS    2
36E1             0560 COUNT      DS    1
36E2             0570 *
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

36E2            0580 **********
36E2            0590 *
36E2            0600 *  RULES    GROUPS 1 AND 2
36E2            0610 *
36E2            0620              ORG   COMJMP+3C0H
23C0            0630 *
23C0            0640 *  PHONEME CQDE DEFINITIONS FOR RULES
23C0            0650 *
23C0            0660 CSPACE       EQU   0
23C0            0670 CTERM        EQU   4
23C0            0680 CUW          EQU   14
23C0            0690 CUX          EQU   18
23C0            0700 CRX          EQU   24
23C0            0710 CLX          EQU   25
23C0            0720 CWX          EQU   26
23C0            0730 CYX          EQU   27
23C0            0740 CWH          EQU   28
23C0            0750 CR           EQU   32
23C0            0760 CW           EQU   34
23C0            0770 CL           EQU   33
23C0            0780 CM           EQU   36
23C0            0790 CN           EQU   37
23C0            0800 CNX          EQU   38
23C0            0810 CP           EQU   39
23C0            0820 CT           EQU   40
23C0            0830 CK           EQU   41
23C0            0840 CKX          EQU   42
23C0            0850 CB           EQU   43
23C0            0860 CD           EQU   44
23C0            0870 CG           EQU   45
23C0            0880 CGX          EQU   46
23C0            0890 CDX          EQU   47
23C0            0900 CS           EQU   50
23C0            0910 CSH          EQU   51
23C0            0920 CZ           EQU   54
23C0            0930 CZH          EQU   55
23C0            0940 CHH          EQU   58
23C0            0950 CQ           EQU   59
23C0            0960 *
23C0            0970 *  DEFINE FEATURE LABELS
23C0            0980 *
23C0            0990 VOWEL        EQU   80H
23C0            1000 CONS         EQU   40H
23C0            1010 FRONT        EQU   20H
23C0            1020 DIPHTH       EQU   10H
23C0            1030 WDBND        EQU   4
23C0            1040 PHBND        EQU   2
23C0            1050 IGNORE       EQU   1
23C0            1060 STOP         EQU   80H
23C0            1070 VOICE        EQU   40H
23C0            1080 PLOS         EQU   20H
23C0            1090 PLOSA        EQU   10H
23C0            1100 FRIC         EQU   8
23C0            1110 LIQUID       EQU   4
23C0            1120 NASAL        EQU   2
23C0            1130 DENTAL       EQU   1
23C0            1140 *
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

23C0            1150 *
23C0            1160 ************
23C0            1170 *
23C0            1180 *  RULES CODE
23C0            1190 *
23C0            1200 ************
23C0            1210 *
23C0            1220 *  RULES MAIN
23C0            1230 *
23C0 CD D8 23   1240 RULES       CALL  RULES1   * APPLY RULE GROUP 1
23C3 C0         1250             RNZ   *        * RETURN IF ERROR
23C4 00         1260             NOP
23C5 00         1270             NOP
23C6 00         1280             NOP
23C7 CD 78 24   1290             CALL  RULES2   * APPLY RULE GROUP 2
23CA 00         1300             NOP
23CB 00         1310             NOP
23CC 00         1320             NOP
23CD CD 15 20   1330             CALL  SETDUR   * ASSIGN INITIAL DURATIONS
23D0 00         1340             NOP
23D1 00         1350             NOP
23D2 00         1360             NOP
23D3 CD 18 20   1370             CALL  RULES3   * APPLY RULE GROUP 3
23D6 AF         1380             XRA   A        * CLEAR ERROR CONDITION
23D7 C9         1390             RET
23D8            1400 *
23D8            1410 *
23D8            1420 **********
23D8            1430 *
23D8            1440 *  RULE GROUP 1
23D8            1450 *
23D8 21 05 35   1460 RULES1      LXI   H,MATRIX+1
23DB 22 00 35   1470             SHLD  MATPTR
23DE 01 5F 00   1480             LXI   B,MATLEN
23E1            1490 R1LOOP      EQU   $
23E1            1500 *
23E1            1510 *  Q <= VOWEL STRESS.GT.0,SPACE//VOWEL STRESS.GT.0
23E1            1520 *
23E1 09         1530 R1A         DAD   B
23E2 7E         1540             MOV   A,M      * GET COL X FEATA
23E3 E6 80      1550             ANI   VOWEL
23E5 CA 1C 24   1560             JZ    R1B      * NOT A VOWEL
23E8 09         1570             DAD   B
23E9 09         1580             DAD   B
23EA 7E         1590             MOV   A,M      * GET COL X STRESS
23EB B7         1600             ORA   A
23EC CA 1C 24   1610             JZ    R1B      * VOWEL NOT STRESSED
23EF 2A 00 35   1620             LHLD  MATPTR
23F2 2B         1630             DCX   H
23F3 7E         1640             MOV   A,M      * GET COL X-1 CODE
23F4 FE 04      1650             CPI   CTERM
23F6 CA 65 24   1660             JZ    ENDR1    * X IS 1ST COLUMN
23F9 FE 00      1670             CPI   CSPACE
23FB C2 1C 24   1680             JNZ   R1B      * NOT A WORD BOUNDARY
23FE 2B         1690             DCX   H
23FF 7E         1700             MOV   A,M      * GET COL X-2 CODE
2400 FE 04      1710             CPI   CTERM
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2402 CA 1C 24    1720             JZ    R1B
2405 09          1730             DAD   B
2406 7E          1740             MOV   A,M      * GET COL X-2 FEATA
2407 E6 80       1750             ANI   VOWEL
2409 CA 1C 24    1760             JZ    R1B      * NOT A VOWEL
240C 09          1770             DAD   B
240D 09          1780             DAD   B
240E 7E          1790             MOV   A,M      * GET COL X-2 STRESS
240F B7          1800             ORA   A
2410 CA 1C 24    1810             JZ    R1B      * STRESS MUST BE NON 0
2413 3E 3B       1820             MVI   A,CQ
2415 CD 0A 27    1830             CALL  MATNSR   * OK, INSERT A GLOTTAL STOP
2418 C0          1840             RNZ
2419 C3 65 24    1850             JMP   ENDR1
241C             1860 *
241C             1870 *  RX <= VOWEL/R/
241C             1880 *
241C 2A 00 35    1890 R1B         LHLD  MATPTR
241F 7E          1900             MOV   A,M
2420 FE 20       1910             CPI   CR       * TEST FOR R
2422 C2 2A 24    1920             JNZ   R1C
2425 16 18       1930             MVI   D,CRX    * CHANGE? TO RX
2427 C3 31 24    1940             JMP   R1BC
242A             1950 *
242A             1960 *  LX <= VOWEL/L/
242A             1970 *
242A FE 21       1980 R1C         CPI   CL       * TEST FOR L
242C C2 46 24    1990             JNZ   R1D
242F 16 19       2000             MVI   D,CLX    * CHANGE? TO LX
2431 2B          2010 R1BC        DCX   H
2432 7E          2020             MOV   A,M      * GET COL X-1 CODE
2433 FE 04       2030             CPI   CTERM
2435 CA 65 24    2040             JZ    ENDR1
2438 09          2050             DAD   B
2439 7E          2060             MOV   A,M      * GET COL X-1 FEATA
243A E6 80       2070             ANI   VOWEL
243C CA 65 24    2080             JZ    ENDR1    * NOT A VOWEL
243F 7A          2090             MOV   A,D
2440 CD 0C 20    2100             CALL  MATPAK   * OK, CHANGE THE CONSONANT
2443 2A 00 35    2110             LHLD  MATPTR
2446             2120 *
2446             2130 *  YX <= DIPHTH FRONT//
2446             2140 *  WX <= DIPHTH -FRONT//
2446             2150 *
2446 2B          2160 R1D         DCX   H
2447 7E          2170             MOV   A,M
2448 FE 04       2180             CPI   CTERM
244A CA 65 24    2190             JZ    ENDR1
244D 09          2200             DAD   B
244E 7E          2210             MOV   A,M      * GET COL X-1 FEATA
244F E6 10       2220             ANI   DIPHTH
2451 CA 65 24    2230             JZ    ENDR1    * NOT A DIPHTHONG
2454 7E          2240             MOV   A,M
2455 E6 20       2250             ANI   FRONT
2457 CA 5F 24    2260             JZ    BACK
245A 3E 1B       2270             MVI   A,CYX
245C C3 61 24    2280             JMP   GLIDE
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

245F 3E 1A       2290 BACK       MVI   A,CWX
2461 CD 0A 27    2300 GLIDE      CALL  MATNSR   * INSERT GLIDE AFTER DIPHTH
2464 C0          2310            RNZ
2465             2320 *
2465             2330 *  END OF RULE GROUP 1
2465             2340 *
2465 00          2350 ENDR1      NOP   *        * BREAKPOINT LOC
2466 2A 00 35    2360            LHLD  MATPTR
2469 23          2370            INX   H
246A 22 00 35    2380            SHLD  MATPTR   * STEP POINTER
246D AF          2390            XRA   A        * CLEAR ERROR CONDITION
246E EB          2400            XCHG
246F 2A 02 35    2410            LHLD  NEGEND
2472 19          2420            DAD   D
2473 D8          2430            RC    *        * RETURN IF END OF MATRIX
2474 EB          2440            XCHG
2475 C3 E1 23    2450            JMP   R1LOOP
2478             2460 *
2478             2470 **********
2478             2480 *
2478             2490 *  RULE GROUP 2
2478             2500 *
2478 21 05 35    2510 RULES2     LXI   H,MATRIX+1
247B 22 00 35    2520            SHLD  MATPTR
247E 01 5F 00    2530            LXI   B,MATLEN
2481             2540 R2LOOP     EQU   $
2481             2550 *
2481             2560 *  STRESSX=1 <= /CONS STRESS.GE.0/VOWEL STRESS.NE.0
2481             2570 *
2481 09          2580 R2A        DAD   B
2482 7E          2590            MOV   A,M      * GET COL X FEATA
2483 E6 40       2600            ANI   CONS
2485 CA FD 25    2610            JZ    R2G      * NOT A CONSONANT
2488 09          2620            DAD   B
2489 09          2630            DAD   B
248A 7E          2640            MOV   A,M      * GET COL X STRESS
248B B7          2650            ORA   A
248C FA AA 24    2660            JM    R2B      * STRESS IS -, DON'T CHANGE IT
248F 2A 00 35    2670            LHLD  MATPTR
2492 23          2680            INX   H
2493 7E          2690            MOV   A,M      * GET COL X+1 CODE
2494 FE 04       2700            CPI   CTERM
2496 CA FD 25    2710            JZ    R2G
2499 09          2720            DAD   B
249A 7E          2730            MOV   A,M      * GET COL X+1 FEATA
249B E6 80       2740            ANI   VOWEL
249D CA AA 24    2750            JZ    R2B      * NOT A VOWEL
24A0 09          2760            DAD   B
24A1 09          2770            DAD   B
24A2 7E          2780            MOV   A,M      * GET COL X+1 STRESS
24A3 B7          2790            ORA   A
24A4 CA 7D 25    2800            JZ    R2E      * VOWEL NOT STRESSED
24A7 2B          2810            DCX   H
24A8 36 01       2820            MVI   M,1      * OK, SET CONSONANT STRESS = 1
24AA             2830 *
24AA             2840 *  STRESSX,X+1=-1 <= /S,PLOS -VOICE/VOWEL STRESS.NE:0
24AA             2850 *
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

24AA 2A 00 35   2860 R2B       LHLD  MATPTR
24AD 7E         2870           MOV   A,M
24AE FE 32      2880           CPI   CS
24B0 C2 E3 24   2890           JNZ   R2C      * COL X NOT AN S
24B3 23         2900           INX   H
24B4 7E         2910           MOV   A,M      * GET COL X+1 CODE
24B5 FE 04      2920           CPI   CTERM
24B7 CA F8 26   2930           JZ    ENDR2    * S IN LAST COL, END GROUP
24BA 09         2940           DAD   B
24BB 09         2950           DAD   B
24BC 7E         2960           MOV   A,M      * GET COL X+1 FEATB
24BD EE 20      2970           XRI   PLOS
24BF E6 60      2980           ANI   PLOS+VOICE
24C1 C2 E3 24   2990           JNZ   R2C      * X+1 IS NOT UNVOICED PLOSIVE
24C4 2A 00 35   3000           LHLD  MATPTR
24C7 23         3010           INX   H
24C8 23         3020           INX   H
24C9 7E         3030           MOV   A,M      * GET COL X+2 CODE
24CA FE 04      3040           CPI   CTERM
24CC CA F8 26   3050           JZ    ENDR2
24CF 09         3060           DAD   B
24D0 7E         3070           MOV   A,M      * GET COL X+2 FEATA
24D1 E6 80      3080           ANI   VOWEL
24D3 CA E3 24   3090           JZ    R2C      * NOT A VOWEL
24D6 09         3100           DAD   B
24D7 09         3110           DAD   B
24D8 7E         3120           MOV   A,M
24D9 B7         3130           ORA   A
24DA CA E3 24   3140           JZ    R2C      * X+2 STRESS MUST BE NON 0
24DD 2B         3150           DCX   H
24DE 36 FF      3160           MVI   M,-1     * SET STRESS X+1 =-1
24E0 2B         3170           DCX   H
24E1 36 FF      3180           MVI   M,-1     * SET STRESS X =-1
24E3            3190 *
24E3            3200 *  STRESSX,X+1=-1 <= /PLOS OR (FRIC -VOICE),LIQUID
24E3            3210 *                        OR NASAL/VOWEL STRESS.NE.0
24E3            3220 *
24E3 2A 00 35   3230 R2C       LHLD  MATPTR
24E6 09         3240           DAD   B
24E7 09         3250           DAD   B
24E8 7E         3260           MOV   A,M      * GET COL X FEATB
24E9 E6 20      3270           ANI   PLOS
24EB C2 F6 24   3280           JNZ   R2C1     * COL X IS PLOSIVE
24EE 7E         3290           MOV   A,M
24EF EE 08      3300           XRI   FRIC
24F1 E6 48      3310           ANI   FRIC+VOICE
24F3 C2 2A 25   3320           JNZ   R2D      * NEITHER PLOS NOR FRIC -VOICE
24F6 2A 00 35   3330 R2C1      LHLD  MATPTR
24F9 23         3340           INX   H
24FA 7E         3350           MOV   A,M      * GET COL X+1 CODE
24FB FE 04      3360           CPI   CTERM
24FD CA 42 26   3370           JZ    R2JK
2500 09         3380           DAD   B
2501 09         3390           DAD   B
2502 7E         3400           MOV   A,M      * GET COL X+1 FEATB
2503 E6 06      3410           ANI   LIQUID+NASAL
2505 CA 2A 25   3420           JZ    R2D      * NEITHER LIQUID NOR NASAL
```

```
ADDR B1 B2 B3 E LINE  LABEL    OPCD  OPERAND

2508 2A 00 35   3430 R2C2      LHLD  MATPTR
250B 23         3440           INX   H
250C 23         3450           INX   H
250D 7E         3460           MOV   A,M        * GET COL X+2 CODE
250E FE 04      3470           CPI   CTERM
2510 CA 42 26   3480           JZ    R2JK
2513 09         3490           DAD   B
2514 7E         3500           MOV   A,M        * GET COL X+2 FEATA
2515 E6 80      3510           ANI   VOWEL
2517 CA 42 26   3520           JZ    R2JK       * NOT A VOWEL
251A 09         3530           DAD   B
251B 09         3540           DAD   B
251C 7E         3550           MOV   A,M
251D B7         3560           ORA   A
251E CA 42 26   3570           JZ    R2JK       * VOWEL X+2 NOT STRESSED
2521 2B         3580           DCX   H
2522 36 FF      3590           MVI   M,-1       * PUT -1 STRESS IN COL X+1
2524 2B         3600           DCX   H
2525 36 FF      3610           MVI   M,-1       * PUT -1 STRESS IN COL X
2527 C3 42 26   3620           JMP   R2JK
252A            3630 *
252A            3640 *   STRESSX,X+1,X+2=-1 <= /S,PLOS -VOICE,LIQUID/
252A            3650 *                         VOWEL STRESS.NE.0
252A            3660 *
252A 2A 00 35   3670 R2D       LHLD  MATPTR
252D 7E         3680           MOV   A,M
252E FE 32      3690           CPI   CS
2530 C2 7D 25   3700           JNZ   R2E        * THIS COL NOT AN S
2533 23         3710           INX   H
2534 7E         3720           MOV   A,M
2535 FE 04      3730           CPI   CTERM
2537 CA F8 26   3740           JZ    ENDR2      * S IN LAST COL, END GROUP 2
253A 09         3750           DAD   B
253B 09         3760           DAD   B
253C 7E         3770           MOV   A,M        * GET COL X+1 FEATB
253D EE 20      3780           XRI   PLOS
253F E6 60      3790           ANI   PLOS+VOICE
2541 C2 F8 26   3800           JNZ   ENDR2      * COL X+1 NOT UNVOICED PLOSIVE
2544 2A 00 35   3810           LHLD  MATPTR
2547 23         3820           INX   H
2548 23         3830           INX   H
2549 7E         3840           MOV   A,M        * GET COL X+2 CODE
254A FE 04      3850           CPI   CTERM
254C CA F8 26   3860           JZ    ENDR2      * LAST COL, END OF GROUP
254F 09         3870           DAD   B
2550 09         3880           DAD   B
2551 7E         3890           MOV   A,M        * GET COL X+2 FEATB
2552 E6 04      3900           ANI   LIQUID
2554 CA F8 26   3910           JZ    ENDR2      * NOT A LIQUID
2557 2A 00 35   3920           LHLD  MATPTR
255A 23         3930           INX   H
255B 23         3940           INX   H
255C 23         3950           INX   H
255D 7E         3960           MOV   A,M        * GET COL X+3 CODE
255E FE 04      3970           CPI   CTERM
2560 CA F8 26   3980           JZ    ENDR2
2563 09         3990           DAD   B
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2564 7E          4000             MOV   A,M      * GET COL X+3 FEATA
2565 E6 80       4010             ANI   VOWEL
2567 CA F8 26    4020             JZ    ENDR2    * NOT A VOWEL
256A 09          4030             DAD   B
256B 09          4040             DAD   B
256C 7E          4050             MOV   A,M      * GET COL X+3 STRESS
256D B7          4060             ORA   A
256E CA F8 26    4070             JZ    ENDR2    * VOWEL MUST BE STRESSED
2571 2B          4080             DCX   H
2572 36 FF       4090             MVI   M,-1     * SET STRESS X+2 = -1
2574 2B          4100             DCX   H
2575 36 FF       4110             MVI   M,-1     * SET STRESS X+1 = -1
2577 2B          4120             DCX   H
2578 36 FF       4130             MVI   M,-1     * SET STRESS X = -1
257A C3 F8 26    4140             JMP   ENDR2
257D             4150 *
257D             4160 *  STRESSX,X+1=-1 <= /T OR D,SH OR ZH/VOWEL STRESS.NE.0
257D             4170 *
257D 2A 00 35    4180 R2E         LHLD  MATPTR
2580 7E          4190             MOV   A,M      * GET COL X CODE
2581 FE 28       4200             CPI   CT
2583 CA 8B 25    4210             JZ    R2E1     * IT'S A T
2586 FE 2C       4220             CPI   CD
2588 C2 1D 26    4230             JNZ   R2H      * IT'S NEITHER T NOR D
258B 23          4240 R2E1        INX   H
258C 7E          4250             MOV   A,M      * GET COL X+1 CODE
258D FE 04       4260             CPI   CTERM
258F CA 42 26    4270             JZ    R2JK     * LAST COL
2592 FE 33       4280             CPI   CSH
2594 CA 9C 25    4290             JZ    R2E2     * COL X+1 IS SH
2597 FE 37       4300             CPI   CZH
2599 C2 BA 25    4310             JNZ   R2F      * X+1 IS NEITHER SH OR ZH
259C 23          4320 R2E2        INX   H
259D 7E          4330             MOV   A,M      * GET COL X+2 CODE
259E FE 04       4340             CPI   CTERM
25A0 CA 42 26    4350             JZ    R2JK     * LAST COL
25A3 09          4360             DAD   B
25A4 7E          4370             MOV   A,M      * GET COL X+2 FEATA
25A5 E6 80       4380             ANI   VOWEL
25A7 CA 42 26    4390             JZ    R2JK     * X+2 NOT A VOWEL
25AA 09          4400             DAD   B
25AB 09          4410             DAD   B
25AC 7E          4420             MOV   A,M      * GET COL X+2 STRESS
25AD B7          4430             ORA   A
25AE CA 42 26    4440             JZ    R2JK     * VOWEL X+2 NOT STRESSED
25B1 2B          4450             DCX   H
25B2 36 FF       4460             MVI   M,-1     * SET STRESS X+1 = -1
25B4 2B          4470             DCX   H
25B5 36 FF       4480             MVI   M,-1     * SET STRESS X = -1
25B7 C3 42 26    4490             JMP   R2JK
25BA             4500 *
25BA             4510 *  DX <= VOWEL/T OR D/(WDBND,VOWEL) OR VOWEL STRESS.EQ.0
25BA             4520 *
25BA 2A 00 35    4530 R2F         LHLD  MATPTR
25BD 2B          4540             DCX   H
25BE 7E          4550             MOV   A,M      * GET COL X-1 CODE
25BF FE 04       4560             CPI   CTERM
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

25C1 CA 42 26    4570            JZ    R2JK      * COL X IS 1ST COL
25C4 09          4580            DAD   B
25C5 7E          4590            MOV   A,M       * GET COL X-1 FEATA
25C6 E6 80       4600            ANI   VOWEL
25C8 CA 42 26    4610            JZ    R2JK      * NOT A VOWEL
25CB 23          4620            INX   H
25CC 23          4630            INX   H
25CD 7E          4640            MOV   A,M       * GET COL X+1 FEATA
25CE E6 04       4650            ANI   WDBND
25D0 C2 E3 25    4660            JNZ   R2F2      * IT'S A WORD BOUNDARY
25D3 7E          4670            MOV   A,M       * GET FEAT A AGAIN
25D4 E6 80       4680            ANI   VOWEL
25D6 CA 42 26    4690            JZ    R2JK      * IT'S NOT A VOWEL
25D9 09          4700            DAD   B
25DA 09          4710            DAD   B
25DB 7E          4720            MOV   A,M       * GET COL X+1 STRESS
25DC B7          4730            ORA   A
25DD CA F5 25    4740            JZ    R2F3      * VOWEL IS UNSTRESSED, DO THE RULE
25E0 C3 42 26    4750            JMP   R2JK
25E3 2A 00 35    4760 R2F2       LHLD  MATPTR
25E6 23          4770            INX   H
25E7 23          4780            INX   H
25E8 7E          4790            MOV   A,M       * GET COL X+2 CODE
25E9 FE 04       4800            CPI   CTERM
25EB CA 42 26    4810            JZ    R2JK
25EE 09          4820            DAD   B
25EF 7E          4830            MOV   A,M
25F0 E6 80       4840            ANI   VOWEL
25F2 CA 42 26    4850            JZ    R2JK      * IT'S NOT A VOWEL
25F5 3E 2F       4860 R2F3       MVI   A,CDX
25F7 CD 0C 20    4870            CALL  MATPAK
25FA C3 F8 26    4880            JMP   ENDR2
25FD             4890 *
25FD             4900 *  UX <= DENTAL/UW/
25FD             4910 *
25FD 2A 00 35    4920 R2G        LHLD  MATPTR
2600 7E          4930            MOV   A,M       * GET COL X CODE
2601 FE 0E       4940            CPI   CUW
2603 C2 1D 26    4950            JNZ   R2H
2606 2B          4960            DCX   H
2607 7E          4970            MOV   A,M       * GET COL X-1 CODE
2608 FE 04       4980            CPI   CTERM
260A CA F8 26    4990            JZ    ENDR2     * UW IS IN COL 1, END OF GROUP
260D 09          5000            DAD   B
260E 09          5010            DAD   B
260F 7E          5020            MOV   A,M       * GET COL X-1 FEATB
2610 E6 01       5030            ANI   DENTAL
2612 CA F8 26    5040            JZ    ENDR2     * NOT A DENTAL CONSONANT
2615 3E 12       5050            MVI   A,CUX
2617 CD 0C 20    5060            CALL  MATPAK    * CHANGE COL TO UX
261A C3 F8 26    5070            JMP   ENDR2
261D             5080 *
261D             5090 *  KX <= /K/VOWEL -FRONT
261D             5100 *
261D FE 29       5110 R2H        CPI   CK
261F C2 27 26    5120            JNZ   R2I       * COL X MUST BE EITHER K, ....
2622 1E 2A       5130            MVI   E,CKX
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2624 C3 2E 26    5140            JMP   R2HI
2627             5150 *
2627             5160 *  GX <= /G/VOWEL -FRONT
2627             5170 *
2627 FE 2D       5180 R2I        CPI   CG
2629 C2 42 26    5190            JNZ   R2JK     * ... OR G
262C 1E 2E       5200            MVI   E,CGX
262E 23          5210 R2HI       INX   H
262F 7E          5220            MOV   A,M      * GET COL X+1 CODE
2630 FE 04       5230            CPI   CTERM
2632 CA 42 26    5240            JZ    R2JK     * PLOSIVE IS IN LAST COL
2635 09          5250            DAD   B
2636 7E          5260            MOV   A,M      * GET COL X+1 FEATA
2637 EE 80       5270            XRI   VOWEL
2639 E6 A0       5280            ANI   VOWEL+FRONT
263B C2 42 26    5290            JNZ   R2JK     * NOT A VOWEL -FRONT
263E 7B          5300            MOV   A,E
263F CD 0C 20    5310            CALL  MATPAK   * CHANGE COL X TO BACK CONSONANT
2642             5320 *
2642             5330 *  ADD 4 TO CODE <= S/PLOS -VOICE/
2642             5340 *  ADD 4 TO CODE <= /PLOS -VOICE/WORDBOUND
2642             5350 *
2642 2A 00 35    5360 R2JK       LHLD  MATPTR
2645 09          5370            DAD   B
2646 09          5380            DAD   B
2647 7E          5390            MOV   A,M      * GET COL X FEATB
2648 EE 20       5400            XRI   PLOS
264A E6 60       5410            ANI   PLOS+VOICE
264C C2 76 26    5420            JNZ   R2L      * NOT AN UNVOICED PLOSIVE
264F 2A 00 35    5430            LHLD  MATPTR
2652 2B          5440            DCX   H
2653 7E          5450            MOV   A,M      * GET COL X-1 CODE
2654 FE 04       5460            CPI   CTERM
2656 CA 5E 26    5470            JZ    R2JK1    * PLOSIVE IS IN 1ST COL
2659 FE 32       5480            CPI   CS
265B CA 6D 26    5490            JZ    R2JK2    * COL X-1 IS S, DO THE RULE
265E 23          5500 R2JK1      INX   H
265F 23          5510            INX   H
2660 7E          5520            MOV   A,M      * GET COL X+1 CODE
2661 FE 04       5530            CPI   CTERM
2663 CA F8 26    5540            JZ    ENDR2    * PLOSIVE IS IN LAST COL
2666 09          5550            DAD   B
2667 7E          5560            MOV   A,M      * GET COL X+1 FEATA
2668 E6 06       5570            ANI   WDBND+PHBND
266A CA 76 26    5580            JZ    R2L      * NOT A BOUNDARY
266D 2A 00 35    5590 R2JK2      LHLD  MATPTR
2670 7E          5600            MOV   A,M
2671 C6 04       5610            ADI   4
2673 CD 0C 20    5620            CALL  MATPAK   * ADD 4 TO CODE IN COL X
2676             5630 *
2676             5640 *  -PLOS -PLOSA <= /PLOS/OPTIONAL WDBOUND,STOP
2676             5650 *
2676 2A 00 35    5660 R2L        LHLD  MATPTR
2679 54          5670            MOV   D,H
267A 5D          5680            MOV   E,L
267B 09          5690            DAD   B
267C 09          5700            DAD   B
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

267D 7E          5710             MOV   A,M     * GET COL X FEATB
267E E6 20       5720             ANI   PLOS
2680 CA F8 26    5730             JZ    ENDR2   * NOT PLOSIVE, END GROUP 2
2683 EB          5740             XCHG  *       * LEAVE DE AT COL X FEATB
2684 23          5750             INX   H
2685 7E          5760             MOV   A,M     * GET COL X+1 CODE
2686 FE 04       5770             CPI   CTERM
2688 CA F8 26    5780             JZ    ENDR2   * PLOS IN LAST COL, END GP 2
268B FE 00       5790             CPI   CSPACE
268D C2 97 26    5800             JNZ   R2L2    * X+1 IS NOT WDBOUND, Y=X+1
2690 23          5810             INX   H       * X+1 IS WDBOUND, Y=X+2
2691 7E          5820             MOV   A,M
2692 FE 04       5830             CPI   CTERM
2694 CA F8 26    5840             JZ    ENDR2   * WDBOUND IS LAST COL
2697 09          5850 R2L2        DAD   B
2698 09          5860             DAD   B
2699 7E          5870             MOV   A,M     * GET COL Y FEATB
269A E6 80       5880             ANI   STOP
269C CA A6 26    5890             JZ    R2M
269F 1A          5900             LDAX  D       * GET COL X FEATB
26A0 E6 CF       5910             ANI   255-PLOS-PLOSA
26A2 12          5920             STAX  D       * DELETE FEATURES PLOS & PLOSA
26A3 C3 F8 26    5930             JMP   ENDR2
26A6             5940 *
26A6             5950 *   -PLOSA <= /PLOSA/OPTIONAL WDBOUND,WH OR HH
26A6             5960 *
26A6 2A 00 35    5970 R2M         LHLD  MATPTR
26A9 54          5980             MOV   D,H
26AA 5D          5990             MOV   E,L
26AB 09          6000             DAD   B
26AC 09          6010             DAD   B
26AD 7E          6020             MOV   A,M     * GET COL X FEATB
26AE E6 10       6030             ANI   PLOSA
26B0 CA F8 26    6040             JZ    ENDR2   * NOT PLOSIVE ASPIRATE, END 2
26B3 EB          6050             XCHG  *       * LEAVE DE AT COL X FEATB
26B4 23          6060             INX   H
26B5 7E          6070             MOV   A,M     * GET COL X+1 CODE
26B6 FE 04       6080             CPI   CTERM
26B8 CA F8 26    6090             JZ    ENDR2   * PLOS ASP IS IN LAST COL
26BB FE 00       6100             CPI   CSPACE
26BD C2 C7 26    6110             JNZ   R2M2    * X+1 IS NOT WDBOUND, Y=X+1
26C0 23          6120             INX   H       * X+1 IS WDBOUND, Y=X+2
26C1 7E          6130             MOV   A,M     * GET COL Y CODE
26C2 FE 04       6140             CPI   CTERM
26C4 CA F8 26    6150             JZ    ENDR2   * WDBOUND IS LAST COL
26C7 FE 1C       6160 R2M2        CPI   CWH
26C9 CA F4 26    6170             JZ    R2MN    * COL Y IS WH, DO THE RULE
26CC FE 3A       6180             CPI   CHH
26CE CA F4 26    6190             JZ    R2MN    * COL Y IS HH, DO THE RULE
26D1             6200 *
26D1             6210 *   -PLOSA <= -BOUNDARY/PLOSA/VOWEL STRESS.EQ.0
26D1             6220 *
26D1 2A 00 35    6230 R2N         LHLD  MATPTR
26D4 23          6240             INX   H
26D5 09          6250             DAD   B
26D6 7E          6260             MOV   A,M     * GET COL X+1 FEATA
26D7 E6 80       6270             ANI   VOWEL
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

26D9 CA F8 26     6280              JZ    ENDR2    * NOT A VOWEL
26DC 09           6290              DAD   B
26DD 09           6300              DAD   B
26DE 7E           6310              MOV   A,M      * GET COL X+1 STRESS
26DF B7           6320              ORA   A
26E0 C2 F8 26     6330              JNZ   ENDR2    * VOWEL IS STRESSED, END GP 2
26E3 2A 00 35     6340              LHLD  MATPTR
26E6 2B           6350              DCX   H
26E7 7E           6360              MOV   A,M      * GET COL X-1 CODE
26E8 FE 04        6370              CPI   CTERM
26EA CA F8 26     6380              JZ    ENDR2
26ED 09           6390              DAD   B
26EE 7E           6400              MOV   A,M      * GET COL X-1 FEATA
26EF E6 06        6410              ANI   WDBND+PHBND
26F1 C2 F8 26     6420              JNZ   ENDR2    * EITHER BOUNDARY STOPS THE RULE
26F4 1A           6430 R2MN         LDAX  D        * GET COL X FEATB
26F5 E6 EF        6440              ANI   255-PLOSA
26F7 12           6450              STAX  D        * DELETE COL X PLOSA FEATURE
26F8              6460 *
26F8              6470 *  END OF RULE GROUP 2
26F8              6480 *
26F8 00           6490 ENDR2        NOP   *        * BREAKPOINT LOC
26F9 2A 00 35     6500              LHLD  MATPTR
26FC 23           6510              INX   H
26FD 22 00 35     6520              SHLD  MATPTR
2700 EB           6530              XCHG
2701 2A 02 35     6540              LHLD  NEGEND
2704 19           6550              DAD   D
2705 D8           6560              RC    *        * RETURN IF AT END OF MATRIX
2706 EB           6570              XCHG
2707 C3 81 24     6580              JMP   R2LOOP
270A              6590 *
270A              6600 **********
270A              6610 *
270A              6620 *  SUBROUTINES
270A              6630 *
270A              6640 *  MOVE DATA IN MATRIX AND INSERT A COLUMN
270A              6650 *
270A 11 61 35     6660 MATNSR       LXI   D,MATRIX+MATLEN-2
270D 2A 02 35     6670              LHLD  NEGEND   * IS THERE ROOM TO INSERT
2710 19           6680              DAD   D
2711 D2 0F 20     6690              JNC   MATERR   * NO
2714 F5           6700              PUSH  PSW      * YES, SAVE THE NEW CODE
2715 2A 00 35     6710              LHLD  MATPTR   * COMPUTE # OF COLS TO MOVE
2718 EB           6720              XCHG
2719 2A 02 35     6730              LHLD  NEGEND
271C 19           6740              DAD   D
271D 7D           6750              MOV   A,L
271E 2F           6760              CMA
271F 3C           6770              INR   A
2720 3C           6780              INR   A
2721 32 E1 36     6790              STA   COUNT
2724 6F           6800              MOV   L,A      * COMPUTE NEW ADDR OF LAST COL
2725 26 00        6810              MVI   H,0
2727 19           6820              DAD   D
2728 22 DF 36     6830              SHLD  MOVAD
272B 2A DF 36     6840 INSR1        LHLD  MOVAD
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

272E 54           6850            MOV   D,H
272F 5D           6860            MOV   E,L
2730 1B           6870            DCX   D
2731 3A E1 36     6880            LDA   COUNT
2734 4F           6890            MOV   C,A
2735 1A           6900 INSR2      LDAX  D          * MOVE A ROW RIGHT 1 LOC
2736 77           6910            MOV   M,A
2737 1B           6920            DCX   D
2738 2B           6930            DCX   H
2739 0D           6940            DCR   C
273A C2 35 27     6950            JNZ   INSR2
273D 2A DF 36     6960            LHLD  MOVAD      * UPDATE NEW POINTER
2740 11 5F 00     6970            LXI   D,MATLEN
2743 19           6980            DAD   D
2744 22 DF 36     6990            SHLD  MOVAD
2747 11 21 C9     7000            LXI   D,-MATEND * ANY MORE ROWS?
274A 19           7010            DAD   D
274B D2 2B 27     7020            JNC   INSR1      * YES
274E F1           7030            POP   PSW        * GET THE NEW CODE
274F CD 0C 20     7040            CALL  MATPAK     * SET CODE AND FEATURES
2752 09           7050            DAD   B
2753 36 00        7060            MVI   M,0        * PUT 0 STRESS IN NEW COL
2755 09           7070            DAD   B
2756 36 00        7080            MVI   M,0        * PUT 0 DURATION IN NEW COL
2758 2A 02 35     7090            LHLD  NEGEND     * DONE, DECREMENT NEGEND
275B 2B           7100            DCX   H
275C 22 02 35     7110            SHLD  NEGEND
275F 2A 00 35     7120            LHLD  MATPTR     * AND INCREMENT MATPTR
2762 23           7130            INX   H
2763 22 00 35     7140            SHLD  MATPTR
2766 AF           7150            XRA   A          * CLEAR ERROR CONDITION
2767 C9           7160            RET
2768              7170 *
2768              7180 *   END OF SECT2
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2000            0010 *  RULES GROUP 3
2000            0020 *
2000            0030 *  SECTION 3 OF THE CSR1 SYNTHESIS BY RULE SYSTEM
2000            0040 *
2000            0050 *  LLOYD RICE,  COMPUTALKER CONSULTANTS
2000            0060 *  VERSION 1.08   MAY 30, 1977
2000            0070 *
2000            0080 **********
2000            0090 *
2000            0100 *  COMMON JUMP ADDRESS TABLE
2000            0110 *
2000            0120 COMJMP      EQU   $
2000            0130 *
2000            0140 CSR1        DS    3
2003            0150 PLAY        DS    3
2006            0160 BUFADR      DS    2
2008            0170 BUFEND      DS    2
200A            0180 PVTAB       DS    2
200C            0190 MATPAK      DS    3
200F            0200 MATERR      DS    3
2012            0210 RULES       DS    3
2015 C3 70 27   0220             JMP   SETDUR
2018 C3 1F 28   0230             JMP   RULES3
201B            0240 GENF0       DS    3
201E            0250 CLRBUF      DS    3
2021            0260 GENPRM      DS    3
2024            0270 MUL         DS    3
2027            0280 DIV         DS    3
202A            0290 DUMMY       DS    16
203A            0300 *
203A            0310 **********
203A            0320 *
203A            0330 *  COMRAM ORIGEN DEFINITION
203A            0340 *
203A            0350             ORG   COMJMP+1500H
3500            0360 COMRAM      EQU   $
3500            0370 *
3500            0380 *  CSR1 SYSTEM RAM SPACE DEFINITION
3500            0390 *
3500            0400 MATPTR      DS    2
3502            0410 NEGEND      DS    2
3504            0420 MATRIX      EQU   $
3504            0430 MATLEN      EQU   95
3504            0440 PHCODE      DS    MATLEN
3563            0450 FEATA       DS    MATLEN
35C2            0460 FEATB       DS    MATLEN
3621            0470 STRES       DS    MATLEN
3680            0480 DUR         DS    MATLEN
36DF            0490 MATEND      EQU   $
36DF            0500 *
36DF            0510 *  RULES GROUP 3 (LOCAL) RAM WORKSPACE
36DF            0520 *
36DF            0530 PREVBD      DS    2
36E1            0540 NV          DS    1
36E2            0550 NEXT        DS    1
36E3            0560 *
36E3            0570 **********
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

36E3            0580 *
36E3            0590 *  CSR1 SECTION 3 CODE
36E3            0600 *
36E3            0610            ORG   COMJMP+770H
2770            0620 SECTAD     EQU   $
2770            0630 *
2770            0640 **********
2770            0650 *
2770            0660 *  PHONEME CODE DEFINITIONS FOR RULES
2770            0670 *
2770            0680 CSPACE     EQU   0
2770            0690 CTERM      EQU   4
2770            0700 CUW        EQU   14
2770            0710 CUX        EQU   18
2770            0720 CRX        EQU   24
2770            0730 CLX        EQU   25
2770            0740 CWX        EQU   26
2770            0750 CYX        EQU   27
2770            0760 CR         EQU   32
2770            0770 CW         EQU   34
2770            0780 CL         EQU   33
2770            0790 CM         EQU   36
2770            0800 CN         EQU   37
2770            0810 CNX        EQU   38
2770            0820 CP         EQU   39
2770            0830 CT         EQU   40
2770            0840 CK         EQU   41
2770            0850 CKX        EQU   42
2770            0860 CE         EQU   43
2770            0870 CD         EQU   44
2770            0880 CG         EQU   45
2770            0890 CGX        EQU   46
2770            0900 CDX        EQU   47
2770            0910 CS         EQU   50
2770            0920 CSH        EQU   51
2770            0930 CZ         EQU   54
2770            0940 CZH        EQU   55
2770            0950 CQ         EQU   59
2770            0960 *
2770            0970 *  DEFINE FEATURE LABELS
2770            0980 *
2770            0990 VOWEL      EQU   80H
2770            1000 CONS       EQU   40H
2770            1010 FRONT      EQU   20H
2770            1020 DIPHTH     EQU   10H
2770            1030 WDBND      EQU   4
2770            1040 PHBND      EQU   2
2770            1050 IGNORE     EQU   1
2770            1060 STOP       EQU   80H
2770            1070 VOICE      EQU   40H
2770            1080 PLOS       EQU   20H
2770            1090 PLOSA      EQU   10H
2770            1100 FRIC       EQU   8
2770            1110 LIQUID     EQU   4
2770            1120 NASAL      EQU   2
2770            1130 DENTAL     EQU   1
2770            1140 *
```

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                                                                  PAGE 03

ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2770            1150 **********
2770            1160 *
2770            1170 *  ALL DURATIONS ARE ASSIGNED AND MANIPULATED
2770            1180 *  IN UNITS OF 2.5 MSEC IN THIS SECTION.
2770            1190 *  FINALLY, AT THE END OF RULES3, THE DURATION
2770            1200 *  VALUES ARE DIVIDED BY 4 TO GIVE UNITS OF
2770            1210 *  10 MSEC, CORRESPONDING TO THE ACTUAL FRAME
2770            1220 *  COUNT FOR EACH PHON (EACH MATRIX COLUMN).
2770            1230 *
2770            1240 *  SET DURATION ROW OF MATRIX FROM TABLE
2770            1250 *
2770 21 05 35   1260 SETDUR     LXI   H,MATRIX+1
2773 22 00 35   1270            SHLD  MATPTR
2776 01 5F 00   1280            LXI   B,MATLEN
2779 5E         1290 SDLOOP     MOV   E,M      * GET CODE X INTO E
277A 09         1300            DAD   B
277B 09         1310            DAD   B
277C 09         1320            DAD   B
277D 7E         1330            MOV   A,M      * GET STRESS X INTO A
277E FE 06      1340            CPI   6
2780 FA 86 27   1350            JM    SD1
2783 3E 00      1360            MVI   A,0      * STRESS.GT.5, SET IT TO 0
2785 77         1370            MOV   M,A
2786 E5         1380 SD1        PUSH  H
2787 C6 FF      1390            ADI   255      * SET CARRY IF A.NE.0
2789 7B         1400            MOV   A,E
278A 17         1410            RAL
278B 5F         1420            MOV   E,A
278C 16 00      1430            MVI   D,0
278E 21 A7 27   1440            LXI   H,DURTAB
2791 19         1450            DAD   D        * COMPUTE LOC IN DURATION TABLE
2792 7E         1460            MOV   A,M      * GET DURATION (IN 2 MSEC UNITS)
2793 E1         1470            POP   H
2794 09         1480            DAD   B
2795 77         1490            MOV   M,A      * PUT OUR VALUE IN THE MATRIX
2796 2A 00 35   1500            LHLD  MATPTR
2799 23         1510            INX   H
279A 22 00 35   1520            SHLD  MATPTR   * INCREMENT POINTER
279D EB         1530            XCHG
279E 2A 02 35   1540            LHLD  NEGEND
27A1 19         1550            DAD   D
27A2 D8         1560            RC    *        * RETURN IF END OF MATRIX
27A3 EB         1570            XCHG
27A4 C3 79 27   1580            JMP   SDLOOP
27A7            1590 *
27A7            1600 *  TABLE OF DURATION VALUES (IN 2.5 MSEC UNITS)
27A7            1610 *  EACH PHON HAS A STRESSED DURATION VALUE
27A7            1620 *  AND AN UNSTRESSED DURATION VALUE.
27A7            1630 *
27A7 00         1640 DURTAB     DB    0     * SPACE (WDBND)
27A8 00         1650            DB    0
27A9 00         1660            DB    0     * PERIOD
27AA 00         1670            DB    0
27AB 48         1680            DB    72    * COMMA (PAUSE)
27AC 48         1690            DB    72
27AD 00         1700            DB    0     * QUEST
27AE 00         1710            DB    0
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

27AF 00          1720            DB    0    * TERM
27B0 00          1730            DB    0
27B1 22          1740            DB    34   * IY, UNSTRESSED
27B2 2B          1750            DB    43   * IY, STRESSED
27B3 1D          1760            DB    29   * IH, UNSTRESSED
27B4 22          1770            DB    34   * IH,    ETC.
27B5 22          1780            DB    34   * EH
27B6 2B          1790            DB    43
27B7 1F          1800            DB    31   * AE
27B8 3A          1810            DB    58
27B9 2B          1820            DB    43   * AA
27BA 3C          1830            DB    60
27BB 18          1840            DB    24   * AH
27BC 2A          1850            DB    42
27BD 30          1860            DB    48   * AO
27BE 40          1870            DB    64
27BF 3A          1880            DB    58   * OW
27C0 3A          1890            DB    58
27C1 29          1900            DB    41   * UH
27C2 2E          1910            DB    46
27C3 24          1920            DB    36   * UW
27C4 38          1930            DB    56
27C5 16          1940            DB    22   * AX
27C6 18          1950            DB    24
27C7 16          1960            DB    22   * IX
27C8 18          1970            DB    24
27C9 2B          1980            DB    43   * ER
27CA 38          1990            DB    56
27CB 24          2000            DB    36   * UX
27CC 38          2010            DB    56
27CD 26          2020            DB    38   * OH
27CE 38          2030            DB    56
27CF 30          2040            DB    48   * AW
27D0 3A          2050            DB    58
27D1 30          2060            DB    48   * AY
27D2 3A          2070            DB    58
27D3 30          2080            DB    48   * OY
27D4 3A          2090            DB    58
27D5 35          2100            DB    53   * EY
27D6 37          2110            DB    55
27D7 26          2120            DB    38   * RX
27D8 30          2130            DB    48
27D9 26          2140            DB    38   * LX
27DA 2B          2150            DB    43
27DB 20          2160            DB    32   * WX
27DC 20          2170            DB    32
27DD 1D          2180            DB    29   * YX
27DE 20          2190            DB    32
27DF 22          2200            DB    34   * WH
27E0 2A          2210            DB    42
27E1 00          2220            DB    0    * EL
27E2 00          2230            DB    0
27E3 00          2240            DB    0    * EM
27E4 00          2250            DB    0
27E5 00          2260            DB    0    * EN
27E6 00          2270            DB    0
27E7 1C          2280            DB    28   * R
```

```
ADDR B1 B2 B3 E LINE   LABEL      OPCD  OPERAND

27E8 28             2290              DB    40
27E9 18             2300              DB    24    * L
27EA 22             2310              DB    34
27EB 20             2320              DB    32    * W
27EC 20             2330              DB    32
27ED 18             2340              DB    24    * Y
27EE 20             2350              DB    32
27EF 1C             2360              DB    28    * M
27F0 1E             2370              DB    30
27F1 1C             2380              DB    28    * N
27F2 1E             2390              DB    30
27F3 1C             2400              DB    28    * NX
27F4 1E             2410              DB    30
27F5 20             2420              DB    32    * P
27F6 20             2430              DB    32
27F7 10             2440              DB    16    * T
27F8 18             2450              DB    24
27F9 18             2460              DB    24    * K
27FA 18             2470              DB    24
27FB 18             2480              DB    24    * KX
27FC 18             2490              DB    24
27FD 18             2500              DB    24    * B
27FE 1A             2510              DB    26
27FF 12             2520              DB    18    * D
2800 14             2530              DB    20
2801 18             2540              DB    24    * G
2802 18             2550              DB    24
2803 18             2560              DB    24    * GX
2804 18             2570              DB    24
2805 0A             2580              DB    10    * DX
2806 0C             2590              DB    12
2807 2A             2600              DB    42    * F
2808 2C             2610              DB    44
2809 26             2620              DB    38    * TH
280A 28             2630              DB    40
280B 30             2640              DB    48    * S
280C 30             2650              DB    48
280D 2C             2660              DB    44    * SH
280E 2C             2670              DB    44
280F 1A             2680              DB    26    * V
2810 1E             2690              DB    30
2811 18             2700              DB    24    * DH
2812 18             2710              DB    24
2813 18             2720              DB    24    * Z
2814 18             2730              DB    24
2815 18             2740              DB    24    * ZH
2816 18             2750              DB    24
2817 00             2760              DB    0     * CH
2818 00             2770              DB    0
2819 00             2780              DB    0     * JH
281A 00             2790              DB    0
281B 18             2800              DB    24    * HH
281C 1C             2810              DB    28
281D 0A             2820              DB    10    * Q
281E 0A             2830              DB    10
281F                2840 *
281F                2850 ***********
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

281F              2860 *
281F              2870 *  RULES GROUP 3
281F              2880 *
281F              2890 **********
281F              2900 *
281F 00           2910 RULES3     NOP
2820 AF           2920            XRA   A
2821 32 E1 36     2930            STA   NV       * CLEAR VOWEL COUNTER (RULE 3A)
2824 32 E2 36     2940            STA   NEXT     * CLEAR NEXT (RULE 3B)
2827 01 5F 00     2950            LXI   B,MATLEN
282A 21 05 35     2960            LXI   H,MATRIX+1
282D 22 00 35     2970            SHLD  MATPTR
2830              2980 R3LOOP     EQU   $
2830              2990 *
2830              3000 *
2830              3010 *  IN THE SPAN BETWEEN TWO WORD OR PHRASE BOUNDARIES
2830              3020 *  CHANGE THE DURATION OF EACH STRESSED VOWEL
2830              3030 *  BY (NV+1)/(2*NV), WHERE NV IS THE NUMBER OF
2830              3040 *  VOWELS IN THE SPAN.
2830              3050 *
2830 09           3060 R3A        DAD   B
2831 01 E1 36     3070            LXI   B,NV
2834 7E           3080            MOV   A,M      * GET COL X FEATA
2835 E6 06        3090            ANI   WDBND+PHBND
2837 C2 46 28     3100            JNZ   R3A2     * EITHER BOUND, COMPUTE THE SPAN
283A 7E           3110            MOV   A,M      * NOT A BOUNDARY, IS IT A VOWEL?
283B E6 80        3120            ANI   VOWEL
283D CA AB 28     3130            JZ    R3B      * NO
2840 0A           3140            LDAX  B        * YES, INCREMENT NV
2841 3C           3150            INR   A
2842 02           3160            STAX  B
2843 C3 AB 28     3170            JMP   R3B
2846 0A           3180 R3A2       LDAX  B        * GET NV
2847 FE 02        3190            CPI   2
2849 DA A1 28     3200            JC    R3A5     * 0 OR 1 VOWEL, NO DUR CHANGE
284C 3C           3210            INR   A
284D 6F           3220            MOV   L,A      * PUT (N+1)*64 IN HL
284E 26 00        3230            MVI   H,0
2850 29           3240            DAD   H
2851 29           3250            DAD   H
2852 29           3260            DAD   H
2853 29           3270            DAD   H
2854 29           3280            DAD   H
2855 29           3290            DAD   H
2856 EB           3300            XCHG  *        * THEN INTO DE
2857 0A           3310            LDAX  B        * GET NV AGAIN
2858 6F           3320            MOV   L,A
2859 26 00        3330            MVI   H,0
285B 23           3340            INX   H
285C CD 27 20     3350            CALL  DIV      * RESULT IS DUR RATIO IN 64THS
285F 7D           3360            MOV   A,L
2860 02           3370            STAX  B        * SAVE IT IN NV
2861 2A DF 36     3380            LHLD  PREVBD
2864 23           3390            INX   H
2865 7C           3400            MOV   A,H      * -(PREVBD)-2 INTO DE
2866 2F           3410            CMA
2867 57           3420            MOV   D,A
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                                                         PAGE 07

ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2868 7D           3430          MOV   A,L
2869 2F           3440          CMA
286A 5F           3450          MOV   E,A
286B 2A 00 35     3460          LHLD  MATPTR
286E 19           3470          DAD   D         * (MATPTR)-(PREVBD)-2 INTO HL
286F 5D           3480          MOV   E,L       * E IS COL COUNTER FOR THE SPAN
2870 01 5F 00     3490 R3A3     LXI   B,MATLEN
2873 2A DF 36     3500          LHLD  PREVBD
2876 23           3510          INX   H         * SCAN THE SPAN
2877 22 DF 36     3520          SHLD  PREVBD
287A 09           3530          DAD   B
287B 7E           3540          MOV   A,M       * GET FEATA
287C E6 80        3550          ANI   VOWEL
287E CA 9D 28     3560          JZ    R3A4      * NOT A VOWEL
2881 09           3570          DAD   B
2882 09           3580          DAD   B
2883 7E           3590          MOV   A,M       * GET THE STRESS VALUE
2884 B7           3600          ORA   A
2885 CA 9D 28     3610          JZ    R3A4      * VOWEL NOT STRESSED
2888 09           3620          DAD   B
2889 3A E1 36     3630          LDA   NV
288C 47           3640          MOV   B,A
288D D5           3650.         PUSH  D
288E 5E           3660          MOV   E,M       * PUT OLD DURATION IN DE
288F CD 24 20     3670          CALL  MUL       * NEW DUR *64 IN HL
2892 EB           3680          XCHG
2893 29           3690          DAD   H
2894 29           3700          DAD   H
2895 EB           3710          XCHG
2896 7B           3720          MOV   A,E       * NEW DUR INTO A
2897 17           3730          RAL
2898 7A           3740          MOV   A,D
2899 CE 00        3750          ACI   0
289B 77           3760          MOV   M,A
289C D1           3770          POP   D
289D 1D           3780 R3A4     DCR   E
289E C2 70 28     3790          JNZ   R3A3
28A1 AF           3800 R3A5     XRA   A
28A2 32 E1 36     3810          STA   NV        * CLEAR THE VOWEL COUNTER
28A5 2A 00 35     3820          LHLD  MATPTR
28A8 22 DF 36     3830          SHLD  PREVBD    * UPDATE PREVBD
28AB              3840 *
28AB              3850 *  DUR*1.38 <= /LAST VOWEL OF A PHRASE, .../PHBND
28AB              3860 *
28AB 2A 00 35     3870 R3B      LHLD  MATPTR
28AE 01 5F 00     3880          LXI   B,MATLEN * RESTORE BC
28B1 09           3890          DAD   B
28B2 7E           3900          MOV   A,M       * GET COL X FEATA
28B3 E6 02        3910          ANI   PHBND
28B5 CA D8 28     3920          JZ    R3C
28B8 2B           3930 R3B2     DCX   H
28B9 7E           3940          MOV   A,M       * GET PREV COL FEATA
28BA E6 02        3950          ANI   PHBND
28BC C2 D8 28     3960          JNZ   R3C       * STOP SCAN IF PHBOUND
28BF E5           3970          PUSH  H
28C0 09           3980          DAD   B
28C1 09           3990          DAD   B
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ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

28C2 09           4000            DAD   B
28C3 46           4010            MOV   B,M       * GET PRESENT DUR INTO B
28C4 1E 58        4020            MVI   E,58H     * 1.38 (SHIFTED) INTO E
28C6 CD 24 20     4030            CALL  MUL       * (B)*(E) INTO DE
28C9 EB           4040            XCHG
28CA 29           4050            DAD   H         * SHIFT BIN PT TO BYTE BOUNDARY
28CB 29           4060            DAD   H
28CC EB           4070            XCHG
28CD 72           4080            MOV   M,D       * UPDATE DURATION
28CE E1           4090            POP   H
28CF 01 5F 00     4100            LXI   B,MATLEN * RESTORE B,C,H,L
28D2 7E           4110            MOV   A,M       * GET FEATA AGAIN
28D3 E6 80        4120            ANI   VOWEL
28D5 CA B8 28     4130            JZ    R3B2      * NOT A VOWEL, CONTINUE
28D8              4140 *
28D8              4150 *  DUR*0.6 <= /VOWEL/PLOS -VOICE
28D8              4160 *
28D8 00           4170 R3C        NOP
28D9 2A 00 35     4180            LHLD  MATPTR
28DC 09           4190            DAD   B
28DD 7E           4200            MOV   A,M       * GET COL X FEATA
28DE E6 80        4210            ANI   VOWEL
28E0 CA 39 29     4220            JZ    R3F       * NOT A VOWEL
28E3 2A 00 35     4230            LHLD  MATPTR
28E6 23           4240            INX   H
28E7 7E           4250            MOV   A,M       * GET COL X+1 CODE
28E8 FE 04        4260            CPI   CTERM
28EA CA DD 2A     4270            JZ    ENDR3
28ED 09           4280            DAD   B
28EE 09           4290            DAD   B
28EF 7E           4300            MOV   A,M       * GET COL X+1 FEATB
28F0 EE 20        4310            XRI   PLOS
28F2 E6 60        4320            ANI   PLOS+VOICE
28F4 C2 FC 28     4330            JNZ   R3D       * NOT AN UNVOICED PLOSIVE
28F7 1E 26        4340            MVI   E,26H     * OK, MULTIPLY BY 0.6 (SHIFTED)
28F9 C3 27 29     4350            JMP   R3CDE
28FC              4360 *
28FC              4370 *  DUR*1.25 <= /VOWEL/FRIC VOICE
28FC              4380 *
28FC 7E           4390 R3D        MOV   A,M       * GET COL X+1 FEATB AGAIN
28FD 2F           4400            CMA
28FE E6 48        4410            ANI   FRIC+VOICE
2900 C2 08 29     4420            JNZ   R3E       * NOT A VOICED FRICATIVE
2903 1E 50        4430            MVI   E,50H     * SET MULTIPLIER TO 1.25 (*64)
2905 C3 27 29     4440            JMP   R3CDE
2908              4450 *
2908              4460 *  DUR*0.5 <= /VOWEL/RX OR LX,CONS
2908              4470 *
2908 2A 00 35     4480 R3E        LHLD  MATPTR
290B 23           4490            INX   H
290C 7E           4500            MOV   A,M       * GET COL X+1 CODE
290D FE 18        4510            CPI   CRX
290F CA 17 29     4520            JZ    R3E2
2912 FE 19        4530            CPI   CLX
2914 C2 DD 2A     4540            JNZ   ENDR3     * NO GOOD, END GROUP 3
2917 23           4550 R3E2       INX   H
2918 7E           4560            MOV   A,M       * GET COL X+2 CODE
```

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ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2919 FE 04       4570            CPI   CTERM
291B CA DD 2A    4580            JZ    ENDR3    * X+1 IS LAST COL
291E 09          4590            DAD   B
291F 7E          4600            MOV   A,M      * GET COL X+2 FEATA
2920 E6 40       4610            ANI   CONS
2922 CA DD 2A    4620            JZ    ENDR3    * NOT A CONSONANT
2925 1E 20       4630            MVI   E,20H    * SET MULTIPLIER TO 0.5 (*64)
2927 2A 00 35    4640 R3CDE      LHLD  MATPTR
292A 09          4650            DAD   B
292B 09          4660            DAD   B
292C 09          4670            DAD   B
292D 46          4680            MOV   B,M      * GET COL X DURATION
292E CD 24 20    4690            CALL  MUL      * MULTIPLY IT BY (E)
2931 EB          4700            XCHG
2932 29          4710            DAD   H
2933 29          4720            DAD   H        * MOVE THE BIN POINT
2934 EB          4730            XCHG
2935 72          4740            MOV   M,D      * & SET NEW DURATION
2936 C3 DD 2A    4750            JMP   ENDR3    * GOTO END OF GROUP
2939             4760 *
2939             4770 *  DUR=90 MSEC <= S/(W OR R OR L) STRESS.LT.0//VOWEEL
2939             4780 *
2939 2A 00 35    4790 R3F        LHLD  MATPTR
293C 7E          4800            MOV   A,M      * GET COL X CODE
293D FE 22       4810            CPI   CW
293F CA 4C 29    4820            JZ    R3F2
2942 FE 20       4830            CPI   CR
2944 CA 4C 29    4840            JZ    R3F2
2947 FE 21       4850            CPI   CL
2949 C2 8D 29    4860            JNZ   R3H      * NOT W OR R OR L
294C 09          4870 R3F2       DAD   B
294D 09          4880            DAD   B
294E 09          4890            DAD   B
294F 7E          4900            MOV   A,M      * GET COL X STRESS
2950 B7          4910            ORA   A
2951 F2 AD 29    4920            JP    R3I      * STRESS.GE.0
2954 2A 00 35    4930            LHLD  MATPTR
2957 23          4940            INX   H
2958 7E          4950            MOV   A,M      * GET COL X+1 CODE
2959 FE 04       4960            CPI   CTERM
295B CA 8D 29    4970            JZ    R3H      * W,R, OR L IS IN LAST COL
295E 09          4980            DAD   B
295F 7E          4990            MOV   A,M      * GET COL X+1 FEATA
2960 E6 80       5000            ANI   VOWEL
2962 CA 8D 29    5010            JZ    R3H      * NOT A VOWEL
2965 2A 00 35    5020            LHLD  MATPTR
2968 2B          5030            DCX   H
2969 7E          5040            MOV   A,M      * GET COL X-1 CODE
296A FE 04       5050            CPI   CTERM
296C CA 8D 29    5060            JZ    R3H      * W, R, OR L IS IN 1ST COL
296F FE 32       5070            CPI   CS
2971 09          5080            DAD   B
2972 09          5090            DAD   B        * MOVE HL TO COL X-1 FEATB
2973 C2 7E 29    5100            JNZ   R3G      * NO S CN COL X-1
2976 23          5110            INX   H
2977 09          5120            DAD   B
2978 09          5130            DAD   B
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ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2979 36 24        5140              MVI   M,36     * SET DURATION TO 90 MSEC
297B C3 8D 29     5150              JMP   R3H
297E              5160 *
297E              5170 *  DUR+20 MSEC <= PLOS -VOICE/(W OR R OR L)
297E              5180 *                   STRESS.LT.0/VOWEL
297E              5190 *
297E 7E           5200 R3G          MOV   A,M      * GET COL X-1 FEATB
297F EE 20        5210              XRI   PLOS
2981 E6 60        5220              ANI   PLOS+VOICE
2983 C2 8D 29     5230              JNZ   R3H      * NOT AN UNVOICED PLOSIVE
2986 23           5240              INX   H
2987 09           5250              DAD   B
2988 09           5260              DAD   B
2989 7E           5270              MOV   A,M      * GET COL X STRESS
298A C6 08        5280              ADI   8        * ADD 20 MSEC
298C 77           5290              MOV   M,A
298D              5300 *
298D              5310 *  DUR*0.8 <= /CONS STRESS.LT.0/
298D              5320 *
298D 2A 00 35     5330 R3H          LHLD  MATPTR
2990 09           5340              DAD   B
2991 09           5350              DAD   B
2992 7E           5360              MOV   A,M      * GET COL X FEATB
2993 E6 40        5370              ANI   CONS
2995 CA DD 2A     5380              JZ    ENDR3    * NOT A CONS, END OF GROUP
2998 09           5390              DAD   B
2999 7E           5400              MOV   A,M      * GET COL X STRESS
299A B7           5410              ORA   A
299B F2 AD 29     5420              JP    R3I      * STRESS IS NOT NEGATIVE
299E 09           5430              DAD   B
299F 46           5440              MOV   B,M      * GET COL X DURATION
29A0 1E 33        5450              MVI   E,33H    * MULTIPLY BY 0.8
29A2 CD 24 20     5460              CALL  MUL
29A5 EB           5470              XCHG
29A6 29           5480              DAD   H        * SHIFT IT OVER
29A7 29           5490              DAD   H
29A8 EB           5500              XCHG
29A9 72           5510              MOV   M,D      * SET NEW DUR
29AA 01 5F 00     5520              LXI   B,MATLEN
29AD              5530 *
29AD              5540 *  DUR=70,60 MSEC <= /T STRESS.GE.0,SH STRESS.GE.0/
29AD              5550 *
29AD 2A 00 35     5560 R3I          LHLD  MATPTR
29B0 54           5570              MOV   D,H
29B1 5D           5580              MOV   E,L
29B2 13           5590              INX   D
29B3 7E           5600              MOV   A,M      * GET COL X CODE
29B4 FE 28        5610              CPI   CT
29B6 C2 DD 29     5620              JNZ   R3J      * NOT T, TRY RULE 3J
29B9 1A           5630              LDAX  D        * GET COL X+1 CODE
29BA FE 04        5640              CPI   CTERM
29BC CA 78 2A     5650              JZ    R3N      * T IS IN LAST COL
29BF FE 33        5660              CPI   CSH
29C1 C2 78 2A     5670              JNZ   R3N      * T BUT NO SH, TRY RULE 3N
29C4 09           5680              DAD   B
29C5 09           5690              DAD   B
29C6 09           5700              DAD   B
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ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

29C7 7E         5710            MOV   A,M      * GET COL X STRESS
29C8 FE 01      5720            CPI   1
29CA FA 06 2A   5730            JM    R3K      * T UNSTRESSED, TRY RULE 3K
29CD 23         5740            INX   H
29CE 7E         5750            MOV   A,M      * GET COL X+1 STRESS
29CF FE 01      5760            CPI   1
29D1 FA 78 2A   5770            JM    R3N      * SH UNSTRESSED, TRY RULE 3N
29D4 09         5780            DAD   B
29D5 36 18      5790            MVI   M,24     * SET COL X+1 DUR TO 60 MSEC
29D7 2B         5800            DCX   H
29D8 36 1C      5810            MVI   M,28     * SEL COL X DUR TO 70 MSEC
29DA C3 78 2A   5820            JMP   R3N
29DD            5830 *
29DD            5840 *  DUR=70,50 MSEC <= /D,STRESS.GT.0,ZH STRESS.GT.0/
29DD            5850 *
29DD FE 2C      5860 R3J        CPI   CD
29DF C2 26 2A   5870            JNZ   R3M      * NOT T OR D, TRY RULE 3M
29E2 1A         5880            LDAX  D
29E3 FE 04      5890            CPI   CTERM
29E5 CA 78 2A   5900            JZ    R3N      * D IS IN LAST COL
29E8 FE 37      5910            CPI   CZH
29EA C2 78 2A   5920            JNZ   R3N      * D BUT NO ZH, TRY RULE 3N
29ED 09         5930            DAD   B
29EE 09         5940            DAD   B
29EF 09         5950            DAD   B
29F0 7E         5960            MOV   A,M      * GET  COL X STRESS
29F1 FE 01      5970            CPI   1
29F3 FA 16 2A   5980            JM    R3L      * D UNSTRESSED, TRY RULE R3L
29F6 23         5990            INX   H
29F7 7E         6000            MOV   A,M      * GET COL X+1 STRESS
29F8 FE 01      6010            CPI   1
29FA FA 78 2A   6020            JM    R3N      * ZH UNSTRESSED, TRY RULE 3N
29FD 09         6030            DAD   B
29FE 36 14      6040            MVI   M,20     * SET X+1 DUR TO 50 MSEC
2A00 2B         6050            DCX   H
2A01 36 1C      6060            MVI   M,28     * SET X DUR TO 70 MSEC
2A03 C3 78 2A   6070            JMP   R3N
2A06            6080 *
2A06            6090 *  DUR=60,40 MSEC <= /T STRESS.EQ.0,SH STRESS.EQ.0/
2A06            6100 *
2A06 23         6110 R3K        INX   H
2A07 7E         6120            MOV   A,M      * GET COL X+1 STRESS
2A08 FE 01      6130            CPI   1
2A0A F2 78 2A   6140            JP    R3N      * SH IS STRESSED, TRY RULE 3N
2A0D 09         6150            DAD   B
2A0E 36 10      6160            MVI   M,16     * SET COL X+1 DUR TO 40 MSEC
2A10 2B         6170            DCX   H
2A11 36 18      6180            MVI   M,24     * SET COL X DUR TO 60 MSEC
2A13 C3 78 2A   6190            JMP   R3N
2A16            6200 *
2A16            6210 *  DUR=40,30 MSEC <= /D STRESS.EQ.0,ZH STRESS.EQ.0/
2A16            6220 *
2A16 23         6230 R3L        INX   H
2A17 7E         6240            MOV   A,M      * GET COL X+1 STRESS
2A18 FE 01      6250            CPI   1
2A1A FA 78 2A   6260            JM    R3N
2A1D 09         6270            DAD   B
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2A1E 36 0C        6280            MVI   M,12      * SET COL X+1 DUR TO 30 MSEC
2A20 2B           6290            DCX   H
2A21 36 10        6300            MVI   M,16      * SET COL X DUR TO 40 MSEC
2A23 C3 78 2A     6310            JMP   R3N
2A26              6320 *
2A26              6330 *  DUR=30,30 MSEC <= /(M,P OR B) OR (N,T OR D) OR
2A26              6340 *                         (NX,K OR KX OR G OR GX)/
2A26              6350 *
2A26 FE 24        6360 R3M        CPI   CM        * TEST COL X CODE
2A28 CA 38 2A     6370            JZ    R3M2      * IT'S M
2A2B FE 25        6380            CPI   CN
2A2D CA 46 2A     6390            JZ    R3M3      * IT'S N
2A30 FE 26        6400            CPI   CNX
2A32 CA 54 2A     6410            JZ    R3M4      * IT'S NX
2A35 C3 78 2A     6420            JMP   R3N
2A38 1A           6430 R3M2       LDAX  D
2A39 FE 27        6440            CPI   CP
2A3B CA 6C 2A     6450            JZ    R3M5      * IT'S M,P
2A3E FE 2B        6460            CPI   CB
2A40 CA 6C 2A     6470            JZ    R3M5      * IT'S M,B
2A43 C3 DD 2A     6480            JMP   ENDR3     * IT'S SOMETHING ELSE
2A46 1A           6490 R3M3       LDAX  D
2A47 FE 28        6500            CPI   CT
2A49 CA 6C 2A     6510            JZ    R3M5      * IT'S N,T
2A4C FE 2C        6520            CPI   CD
2A4E CA 6C 2A     6530            JZ    R3M5      * IT'S N,D
2A51 C3 DD 2A     6540            JMP   ENDR3     * IT'S SOMETHING ELSE
2A54 1A           6550 R3M4       LDAX  D
2A55 FE 29        6560            CPI   CK
2A57 CA 6C 2A     6570            JZ    R3M5      * IT'S NX,K
2A5A FE 2A        6580            CPI   CKX
2A5C CA 6C 2A     6590            JZ    R3M5      * IT'S NX,KX
2A5F FE 2D        6600            CPI   CG
2A61 CA 6C 2A     6610            JZ    R3M5      * IT'S NX,G
2A64 FE 2E        6620            CPI   CGX
2A66 CA 6C 2A     6630            JZ    R3M5      * IT'S NX,GX
2A69 C3 DD 2A     6640            JMP   ENDR3     * IT'S SOMETHING ELSE
2A6C 09           6650 R3M5       DAD   B
2A6D 09           6660            DAD   B
2A6E 09           6670            DAD   B
2A6F 09           6680            DAD   B
2A70 36 0C        6690            MVI   M,12      * SET COL X DUR TO 30 MSEC
2A72 23           6700            INX   H
2A73 36 0C        6710            MVI   M,12      * SET COL X+1 DUR TO 30 MSEC
2A75 C3 DD 2A     6720            JMP   ENDR3
2A78              6730 *
2A78              6740 *  DUR*0.5 <= PLOS,OPTIONAL WDBOUND/PLOS/
2A78              6750 *
2A78 2A 00 35     6760 R3N        LHLD  MATPTR
2A7B 09           6770            DAD   B
2A7C 09           6780            DAD   B
2A7D 7E           6790            MOV   A,M       * GET COL X FEATB
2A7E E6 20        6800            ANI   PLOS
2A80 CA DD 2A     6810            JZ    ENDR3     * NOT A PLOSIVE, END OF GROUP
2A83 2A 00 35     6820            LHLD  MATPTR
2A86 2B           6830            DCX   H
2A87 7E           6840            MOV   A,M       * GET COL X-1 CODE
```

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ADDR B1 B2 B3 E LINE  LABEL    OPCD  OPERAND

2A88 FE 04      6850           CPI   CTERM
2A8A CA A6 2A   6860           JZ    R3N3       * X IS 1ST COL, TRY PLOS AFTER
2A8D 54         6870           MOV   D,H
2A8E 5D         6880           MOV   E,L
2A8F 09         6890           DAD   B
2A90 7E         6900           MOV   A,M        * GET COL X-1 FEATA
2A91 E6 04      6910           ANI   WDBND
2A93 CA 9F 2A   6920           JZ    R3N2       * NOT A WDBND, TEST FOR PLOSIVE
2A96 EB         6930           XCHG
2A97 2B         6940           DCX   H
2A98 7E         6950           MOV   A,M        * GET COL X-2 CODE
2A99 FE 04      6960           CPI   CTERM
2A9B CA A6 2A   6970           JZ    R3N3
2A9E 09         6980           DAD   B
2A9F 09         6990 R3N2      DAD   B          * MOVE TO FEATB
2AA0 7E         7000           MOV   A,M
2AA1 E6 20      7010           ANI   PLOS
2AA3 C2 C9 2A   7020           JNZ   R3N5       * OK, DO RULE 3N
2AA6            7030 *
2AA6            7040 *  DUR*0.5 <= /PLOS/OPTIONAL WDBOUND,PLOS
2AA6            7050 *
2AA6 2A 00 35   7060 R3N3      LHLD  MATPTR
2AA9 23         7070           INX   H
2AAA 7E         7080           MOV   A,M        * GET COL X+1 CODE
2AAB FE 04      7090           CPI   CTERM
2AAD CA DD 2A   7100           JZ    ENDR3      * X IS LAST COL, END GROUP
2AB0 54         7110           MOV   D,H
2AB1 5D         7120           MOV   E,L
2AB2 09         7130           DAD   B
2AB3 7E         7140           MOV   A,M        * GET COL X+1 FEATA
2AB4 E6 04      7150           ANI   WDBND
2AB6 CA C2 2A   7160           JZ    R3N4       * NOT A WDBND, TEST FOR PLOS
2AB9 EB         7170           XCHG
2ABA 23         7180           INX   H
2ABB 7E         7190           MOV   A,M        * GET COL X+2 CODE
2ABC FE 04      7200           CPI   CTERM
2ABE CA DD 2A   7210           JZ    ENDR3
2AC1 09         7220           DAD   B
2AC2 09         7230 R3N4      DAD   B          * MOVE TO FEATB
2AC3 7E         7240           MOV   A,M
2AC4 E6 20      7250           ANI   PLOS
2AC6 CA DD 2A   7260           JZ    ENDR3      * NO, END GROUP 3
2AC9 2A 00 35   7270 R3N5      LHLD  MATPTR
2ACC 09         7280           DAD   B
2ACD 09         7290           DAD   B
2ACE 09         7300           DAD   B
2ACF 09         7310           DAD   B
2AD0 C5         7320           PUSH  B
2AD1 46         7330           MOV   B,M        * GET COL X DURATION
2AD2 1E 20      7340           MVI   E,20H      * MULTIPLY BY 0.5
2AD4 CD 24 20   7350           CALL  MUL
2AD7 EB         7360           XCHG
2AD8 29         7370           DAD   H
2AD9 29         7380           DAD   H
2ADA EB         7390           XCHG
2ADB 72         7400           MOV   M,D        * STORE NEW DURATION
2ADC C1         7410           POP   B
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2ADD            7420 *
2ADD            7430 *  END OF RULE GROUP 3
2ADD            7440 *
2ADD 2A 00 35   7450 ENDR3       LHLD  MATPTR
2AE0 23         7460             INX   H
2AE1 22 00 35   7470             SHLD  MATPTR
2AE4 EB         7480             XCHG
2AE5 2A 02 35   7490             LHLD  NEGEND
2AE8 19         7500             DAD   D
2AE9 EB         7510             XCHG
2AEA D2 30 28   7520             JNC   R3LOOP   * LOOP AGAIN IF NOT DONE
2AED            7530 *
2AED            7540 *  READJUST DURATIONS FROM 2.5 MSEC TO 10 MSEC
2AED            7550 *   (SO DUR UNIT = FRAME TIME)
2AED            7560 *
2AED 11 FB CA   7570             LXI   D,-MATRIX-1
2AF0 19         7580             DAD   D
2AF1 4D         7590             MOV   C,L
2AF2 21 80 36   7600             LXI   H,DUR
2AF5 23         7610 ADJDUR      INX   H
2AF6 7E         7620             MOV   A,M
2AF7 B7         7630             ORA   A        * CLEAR CARRY, DIV BY SHIFTING
2AF8 1F         7640             RAR
2AF9 B7         7650             ORA   A
2AFA 1F         7660             RAR
2AFB CE 00      7670             ACI   0        * ROUND UP 1 IF CARRY SET
2AFD 77         7680             MOV   M,A
2AFE 0D         7690             DCR   C
2AFF C2 F5 2A   7700             JNZ   ADJDUR
2B02 C9         7710             RET
2B03            7720 *
2B03            7730 *  END OF SECT3
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2000            0010 *  GENF0
2000            0020 *
2000            0030 *  SECTION 4 OF THE CSR1 SYNTHESIS BY RULE SYSTEM
2000            0040 *
2000            0050 *  LLOYD RICE,  COMPUTALKER CONSULTANTS
2000            0060 *  VERSION 1.11   MAAY 30, 1977
2000            0070 *
2000            0080 **********
2000            0090 *
2000            0100 *  COMMON JUMP ADDRESS TABLE
2000            0110 *
2000            0120 COMJMP     EQU   $
2000            0130 *
2000            0140 CSR1       DS    3
2003            0150 PLAY       DS    3
2006            0160 BUFADR     DS    2
2008            0170 BUFEND     DS    2
200A            0180 PVTAB      DS    2
200C            0190 MATPAK     DS    3
200F            0200 MATERR     DS    3
2012            0210 RULES      DS    3
2015            0220 SETDUR     DS    3
2018            0230 RULES3     DS    3
201B C3 10 2B   0240            JMP   GENF0
201E C3 D9 2D   0250            JMP   CLRBUF
2021            0260 GENPRM     DS    3
2024            0270 MUL        DS    3
2027            0280 DIV        DS    3
202A            0290 DUMMY      DS    16
203A            0300 *
203A            0310 **********
203A            0320 *
203A            0330 *  COMRAM ORIGEN DEFINITION
203A            0340 *
203A            0350            ORG   COMJMP+1500H
3500            0360 COMRAM     EQU   $
3500            0370 *
3500            0380 *  CSR1 SYSTEM RAM SPACE DEFINITION
3500            0390 *
3500            0400 MATPTR     DS    2
3502            0410 NEGEND     DS    2
3504            0420 MATRIX     EQU   $
3504            0430 MATLEN     EQU   95
3504            0440 PHCODE     DS    MATLEN
3563            0450 FEATA      DS    MATLEN
35C2            0460 FEATB      DS    MATLEN
3621            0470 STRES.     DS    MATLEN
3680            0480 DUR        DS    MATLEN
36DF            0490 MATEND     EQU   $
36DF            0500 BUFPTR     DS    2
36E1            0510 *
36E1            0520 *  GENF0 (LOCAL) RAM WORKSPACE
36E1            0530 *
36E1            0540 STRSX      DS    1
36E2            0550 DURX       DS    1
36E3            0560 DURX4      DS    1
36E4            0570 HF0        DS    2
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

36E6             0580 FTERM      DS    1
36E7             0590 DELTA      DS    2
36E9             0600 SD         DS    2
36EB             0610 NEGBUF     DS    2
36ED             0620 NEGPSE     DS    2
36EF             0630 NEGBND     DS    2
36F1             0640 *
36F1             0650 **********  .
36F1             0660 *
36F1             0670 *  GENFO
36F1             0680 *
36F1             0690            ORG   COMJMP+0B10H
2B10             0700 SECTAD     EQU   $
2B10             0710 *
2B10             0720 **********
2B10             0730 *
2B10             0740 *  PHONEME CODE DEFINITIONS FOR GENFO
2B10             0750 *
2B10             0760 CPER       EQU   1
2B10             0770 CQUEST     EQU   3
2B10             0780 CTERM      EQU   4
2B10             0790 *
2B10             0800 *  FEATURE LABEL DEFS FOR GENFO
2B10             0810 *
2B10             0820 VOWEL      EQU   80H
2B10             0830 WDBND      EQU   4
2B10             0840 VOICE      EQU   40H
2B10             0850 *
2B10             0860 **********
2B10             0870 *
2B10 2A 06 20    0880 GENFO      LHLD  BUFADR   * GET (BUFADR) IN DE
2B13 EB          0890            XCHG
2B14 21 0B 00    0900            LXI   H,11
2B17 19          0910            DAD   D
2B18 0E 09       0920            MVI   C,9
2B1A 2B          0930            DCX   H
2B1B 36 00       0940            MVI   M,0      * CLEAR FRAME 1
2B1D 0D          0950            DCR   C
2B1E C2 1A 2B    0960            JNZ   $-4
2B21 23          0970            INX   H
2B22 22 DF 36    0980            SHLD  BUFPTR   * POINT TO F0 BYTE IN FRAME 1
2B25 7A          0990            MOV   A,D
2B26 2F          1000            CMA
2B27 67          1010            MOV   H,A
2B28 47          1020            MOV   B,A
2B29 7B          1030            MOV   A,E
2B2A 2F          1040            CMA
2B2B 6F          1050            MOV   L,A
2B2C 4F          1060            MOV   C,A
2B2D 2B          1070            DCX   H
2B2E 2B          1080            DCX   H
2B2F 22 EB 36    1090            SHLD  NEGBUF   * NEGBUF=-(BUFADR)-3
2B32 21 5E FF    1100            LXI   H,-9*18
2B35 09          1110            DAD   B        * NEGPSE = -ADDR OF F0 PARAM
2B36 22 ED 36    1120            SHLD  NEGPSE   *  IN LAST FRAME OF INITIAL PAUSE
2B39 2A 08 20    1130            LHLD  BUFEND   * GET LAST AVAILABLE BUFFER LOC
2B3C 09          1140            DAD   B
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2B3D EB             1150             XCHG
2B3E 21 09 00       1160             LXI   H,9
2B41 CD 27 20       1170             CALL  DIV      * DIVIDE AVAILABLE SPACE BY 9
2B44 54             1180             MOV   D,H      * IGNORE REMAINDER
2B45 5D             1190             MOV   E,L      * MOVE MAX FRAME COUNT TO DE
2B46 29             1200             DAD   H
2B47 29             1210             DAD   H
2B48 29             1220             DAD   H
2B49 19             1230             DAD   D        * (HL) = 9*FRAME COUNT
2B4A 0B             1240             DCX   B        * (BC) = -(BUFADR)-2
2B4B 79             1250             MOV   A,C
2B4C 95             1260             SUB   L
2B4D 6F             1270             MOV   L,A
2B4E 78             1280             MOV   A,B
2B4F 9C             1290             SBB   H
2B50 67             1300             MOV   H,A
2B51 22 EF 36       1310             SHLD  NEGBND   * -(BUFADR)-2-9*MAX FRAME CNT
2B54 21 05 35       1320             LXI   H,MATRIX+1
2B57 22 00 35       1330             SHLD  MATPTR   * POINT TO MAT COL 2 (AFTER #)
2B5A                1340 *
2B5A                1350 ******
2B5A                1360 *
2B5A                1370 *  EACH PASS THRU F0LOOP GENERATES F0 DATA INTO
2B5A                1380 *  FRAMES I+1 THRU I+DURATION X, CORRESPONDING TO
2B5A                1390 *  THE PHONEME IN MATRIX COLUMN X.  BUFPTR ALWAYS
2B5A                1400 *  POINTS TO F0(I) AT THE BEGINNING OF THE LOOP.
2B5A                1410 *
2B5A 00             1420 F0LOOP      NOP   *        * BREAKPOINT LOC
2B5B 2A 00 35       1430             LHLD  MATPTR
2B5E 01 5F 00       1440             LXI   B,MATLEN
2B61 5E             1450             MOV   E,M      * GET COL X CODE IN E
2B62 09             1460             DAD   B
2B63 56             1470             MOV   D,M      * GET COL X FEATA IN D
2B64 09             1480             DAD   B
2B65 7E             1490             MOV   A,M      * GET COL X FEATB IN A
2B66 09             1500             DAD   B        * MOVE PTR TO STRESS X
2B67 E6 40          1510             ANI   VOICE
2B69 C2 22 2C       1520             JNZ   VOICED   * IT'S A VOICED PHONEME
2B6C 09             1530             DAD   B
2B6D 7E             1540             MOV   A,M
2B6E 32 E2 36       1550             STA   DURX     * SAVE DURATION X
2B71 7B             1560             MOV   A,E
2B72 1E D8          1570             MVI   E,-40    * TERMINAL DROP IF "."
2B74 FE 01          1580             CPI   CPER
2B76 CA 80 2B       1590             JZ    ENDS
2B79 1E 28          1600             MVI   E,40     * TERMINAL RISE IF "?"
2B7B FE 03          1610             CPI   CQUEST
2B7D C2 13 2C       1620             JNZ   NOF0
2B80                1630 *
2B80                1640 *  COMPUTE PHRASE-TERMINAL F0 CHANGE
2B80                1650 *  ENTER WITH F0 OFFSET IN E
2B80                1660 *
2B80 7B             1670 ENDS        MOV   A,E
2B81 32 E6 36       1680             STA   FTERM    * SAVE F0 CHANGE VALUE
2B84 AF             1690             XRA   A
2B85 01 F7 FF       1700             LXI   B,-9
2B88 2A DF 36       1710             LHLD  BUFPTR   * SCAN BACK FOR LAST NON 0 F0
```

```
ADDR B1 B2 B3 E LINE  LABEL       OPCD  OPERAND

2B8B B6           1720 ENDS1       ORA   M
2B8C C2 9C 2B     1730             JNZ   RAMP     * FOUND A NON 0 VALUE
2B8F 09           1740             DAD   B
2B90 EB           1750             XCHG
2B91 2A EB 36     1760             LHLD  NEGBUF
2B94 19           1770             DAD   D
2B95 D2 13 2C     1780             JNC   NOF0     * HIT FRONT OF BUFFER, EXIT
2B98 EB           1790             XCHG
2B99 C3 8B 2B     1800             JMP   ENDS1
2B9C 3A E6 36     1810 RAMP        LDA   FTERM    * NON 0 F0 + CHANGE
2B9F 86           1820             ADD   M
2BA0 FE 0F        1830             CPI   15
2BA2 D2 AA 2B     1840             JNC   RAMP1
2BA5 3E 0F        1850             MVI   A,15     * FINAL F0 < 15, MAKE IT 15
2BA7 C3 B1 2B     1860             JMP   RAMP2
2BAA FE 7D        1870 RAMP1       CPI   125
2BAC DA B1 2B     1880             JC    RAMP2
2BAF 3E 7D        1890             MVI   A,125    * FINAL F0 > 125, MAKE IT 125
2BB1 96           1900 RAMP2       SUB   M
2BB2 32 E6 36     1910             STA   FTERM    * THE REAL FINAL F0 OFFSET
2BB5 EB           1920             XCHG  *        * END-OF-RAMP ADDR TO DE
2BB6 06 1D        1930             MVI   B,29     * TRY TO MAKE A 290 MSEC RAMP
2BB8 05           1940 RAMP3       DCR   B
2BB9 78           1950             MOV   A,B      * TENTATIVE RAMP LENGTH
2BBA 87           1960             ADD   A
2BBB 87           1970             ADD   A
2BBC 87           1980             ADD   A
2BBD 80           1990             ADD   B
2BBE 2F           2000             CMA
2BBF 3C           2010             INR   A
2BC0 4F           2020             MOV   C,A      * -9*TRL INTO A AND C
2BC1 2A ED 36     2030             LHLD  NEGPSE
2BC4 19           2040             DAD   D        * AVAILABLE SPACE IN HL
2BC5 85           2050             ADD   L
2BC6 3E FF        2060             MVI   A,0FFH
2BC8 8C           2070             ADC   H
2BC9 D2 B8 2B     2080             JNC   RAMP3    * NO ROOM, SHORTEN RAMP
2BCC 69           2090             MOV   L,C
2BCD 26 FF        2100             MVI   H,0FFH
2BCF 19           2110             DAD   D
2BD0 E5           2120             PUSH  H        * BEGIN-RAMP ADDR, SAVE IT
2BD1 3A E6 36     2130             LDA   FTERM
2BD4 4F           2140             MOV   C,A
2BD5 B7           2150             ORA   A
2BD6 F2 DB 2B     2160             JP    $+5      * OFFSET IS +
2BD9 2F           2170             CMA
2BDA 3C           2180             INR   A        * OFFSET IS -, MAKE IT +
2BDB 57           2190             MOV   D,A
2BDC 1E 00        2200             MVI   E,0      * 256*OFFSET INTO DE
2BDE 68           2210             MOV   L,B
2BDF 26 00        2220             MVI   H,0      * RAMP FRAME COUNT IN HL
2BE1 CD 27 20     2230             CALL  DIV
2BE4 79           2240             MOV   A,C
2BE5 B7           2250             ORA   A
2BE6 F2 F0 2B     2260             JP    RAMP4    * OFFSET IS +, OK
2BE9 7C           2270             MOV   A,H      * OFFSET IS -, MAKE DELTA -
2BEA 2F           2280             CMA
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2BEB 67          2290            MOV   H,A
2BEC 7D          2300            MOV   A,L
2BED 2F          2310            CMA
2BEE 6F          2320            MOV   L,A
2BEF 23          2330            INX   H
2BF0 22 E7 36    2340 RAMP4      SHLD  DELTA    * DELTA=256*OFFSET/RAMP LENGTH
2BF3 11 00 00    2350            LXI   D,0
2BF6 C3 FD 2B    2360            JMP   RAMP5+4
2BF9 E5          2370 RAMP5      PUSH  H        * SAVE BUFFER POINTER
2BFA 2A E7 36    2380            LHLD  DELTA
2BFD 19          2390            DAD   D        * DIF=DIF+DELTA
2BFE E3          2400            XTHL  *   -    * DIF TO STACK
2BFF EB          2410            XCHG  *        * BUFFER PTR TO DE
2C00 21 09 00    2420            LXI   H,9
2C03 19          2430            DAD   D        * UPDATE BUFFER PTR
2C04 D1          2440            POP   D        * DIF TO DE
2C05 7E          2450            MOV   A,M      * F0=OLDF0+DIF/256
2C06 B7          2460            ORA   A
2C07 CA 0C 2C    2470            JZ    $+5      * IT' 0, DON'T CHANGE IT
2C0A 82          2480            ADD   D
2C0B 77          2490            MOV   M,A
2C0C 05          2500            DCR   B
2C0D C2 F9 2B    2510            JNZ   RAMP5
2C10 C3 E7 2C    2520            JMP   ENDF0
2C13             2530 *
2C13             2540 *  UNVOICED PHON, GENERATE ARC TO STRESS 2 LEVEL
2C13             2550 *
2C13 3A E2 36    2560 NOF0       LDA   DURX
2C16 4F          2570            MOV   C,A
2C17 06 05       2580            MVI   B,5
2C19 2A DF 36    2590            LHLD  BUFPTR
2C1C CD 12 2D    2600            CALL  FPARAB   * PARABOLA PEAKS AT END OF PHON
2C1F C3 E7 2C    2610            JMP   ENDF0
2C22             2620 *
2C22             2630 *  GENERATE F0 FOR VOICED PHONS
2C22             2640 *  ON ENTRY: (D)=FEATA X, (B)=MATLEN
2C22             2650 *              HL POINTS TO STRESS X
2C22             2660 *
2C22 5E          2670 VOICED     MOV   E,M      * GET STRESS X IN E
2C23 09          2680            DAD   B
2C24 7E          2690            MOV   A,M
2C25 32 E2 36    2700            STA   DURX     * GET DUR X & SAVE IT
2C28 7A          2710            MOV   A,D      * GET FEATA X
2C29 E6 80       2720            ANI   VOWEL
2C2B CA 63 2C    2730            JZ    VNEXT    * X NOT A VOWEL, TRY X+1
2C2E 7B          2740            MOV   A,E      * X IS VOWEL, SEE IF STRESSED
2C2F B7          2750            ORA   A
2C30 CA 63 2C    2760            JZ    VNEXT    * NO, TRY X+1
2C33 32 E1 36    2770            STA   STRSX    * SAVE STRESS VALUE
2C36 06 00       2780            MVI   B,0
2C38 3A E2 36    2790            LDA   DURX     * GET DURX AGAIN
2C3B B7          2800 VSTRS      ORA   A        * DIVIDE IT BY 4
2C3C 1F          2810            RAR
2C3D B7          2820            ORA   A
2C3E 1F          2830            RAR
2C3F 80          2840            ADD   B        * ADD EITHER 0 OR DURX
2C40 32 E3 36    2850            STA   DURX4    * EITHER DURX/4 OR DURX+DURY/4
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2C43 4F            2860            MOV   C,A
2C44 3A E1 36      2870            LDA   STRSX    * MOVE STRESS INTO B
2C47 47            2880            MOV   B,A
2C48 2A DF 36      2890            LHLD  BUFPTR
2C4B CD 12 2D      2900            CALL  FPARAB   * COMPUTE FRONT OF PARABOLA
2C4E C0            2910            RNZ   *        * ERROR RETURN
2C4F 3A E3 36      2920            LDA   DURX4
2C52 47            2930            MOV   B,A
2C53 3A E2 36      2940            LDA   DURX
2C56 90            2950            SUB   B
2C57 4F            2960            MOV   C,A      * FULL DUR - FRONT DUR INTO C
2C58 3A E1 36      2970            LDA   STRSX
2C5B 47            2980            MOV   B,A
2C5C CD 7F 2D      2990            CALL  BPARAB   * COMPUTE BACK OF PARABOLA
2C5F C0            3000            RNZ   *        * ERROR RETURN
2C60 C3 E7 2C      3010            JMP   ENDF0
2C63               3020 *
2C63               3030 *  CURRENT VOICED PHON IS NOT A STRESSED VOWEL
2C63               3040 *  IF NEXT ONE IS, GENERATE PARABOLA ACROSS BOTH
2C63               3050 *
2C63 2A DF 36      3060 VNEXT      LHLD  BUFPTR   * GET LAST F0 OF PREV PHON
2C66 7E            3070            MOV   A,M
2C67 B7            3080            ORA   A
2C68 C2 6D 2C      3090            JNZ   $+5
2C6B 36 45         3100            MVI   M,69     * LAST F0 WAS 0, MAKE IT 69
2C6D 2A 00 35      3110            LHLD  MATPTR
2C70 23            3120 VNXT1      INX   H
2C71 54            3130            MOV   D,H
2C72 5D            3140            MOV   E,L
2C73 7E            3150            MOV   A,M      * GET NEXT COL CODE
2C74 FE 04         3160            CPI   CTERM
2C76 CA A6 2C      3170            JZ    DOWNDR   * END OF MATRIX, FINISB X
2C79 09            3180            DAD   B
2C7A 7E            3190            MOV   A,M
2C7B E6 04         3200            ANI   WDBND
2C7D CA 84 2C      3210            JZ    VNXT2    * NOT A WORD BOUNDARY
2C80 EB            3220            XCHG
2C81 C3 70 2C      3230            JMP   VNXT1    * X+1 IS WDBOUND, BUMP AGAIN
2C84 7E            3240 VNXT2      MOV   A,M      * GET COL Y FEATA
2C85 E6 80         3250            ANI   VOWEL
2C87 CA A6 2C      3260            JZ    DOWNDR   * Y NOT A VOWEL, DOWNDRIFT X
2C8A 09            3270            DAD   B
2C8B 09            3280            DAD   B
2C8C 7E            3290            MOV   A,M      * GET COL Y STRESS
2C8D B7            3300            ORA   A
2C8E CA A6 2C      3310            JZ    DOWNDR   * Y IS VOWEL BUT NOT STRESSED
2C91 32 E1 36      3320            STA   STRSX
2C94 09            3330            DAD   B
2C95 4E            3340            MOV   C,M      * GET COL Y DURATION
2C96 3A E2 36      3350            LDA   DURX
2C99 47            3360            MOV   B,A
2C9A 81            3370            ADD   C
2C9B 32 E2 36      3380            STA   DURX     * DURX=DUR X + DUR Y
2C9E EB            3390            XCHG
2C9F 22 00 35      3400            SHLD  MATPTR   * MOVE MATPTR UP TO COL Y
2CA2 79            3410            MOV   A,C      * GET COL Y DURATION
2CA3 C3 3B 2C      3420            JMP   VSTRS
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2CA6               3430 *
2CA6               3440 *  LET F0 DRIFT DOWNWARD TOWARD 43 (100 HZ)
2CA6               3450 *
2CA6 2A 00 35      3460 DOWNDR      LHLD  MATPTR
2CA9 01 7C 01      3470             LXI   B,MATLEN*4
2CAC 09            3480             DAD   B
2CAD 4E            3490             MOV   C,M      * GET DUR X IN C
2CAE 2A DF 36      3500             LHLD  BUFPTR
2CB1 56            3510             MOV   D,M      * GET PREVIOUS F0 IN D
2CB2 1E 00         3520             MVI   E,0
2CB4 D5            3530             PUSH  D
2CB5 E3            3540 DWN1        XTHL  *        * BUFPTR TO STACK, GET F0
2CB6 7C            3550             MOV   A,H      * SHIFT HL RIGHT 5
2CB7 29            3560             DAD   H
2CB8 29            3570             DAD   H
2CB9 29            3580             DAD   H
2CBA 6C            3590             MOV   L,H
2CBB 07            3600             RLC
2CBC 07            3610             RLC
2CBD 07            3620             RLC
2CBE E6 07         3630             ANI   7
2CC0 67            3640             MOV   H,A
2CC1 2F            3650             CMA
2CC2 57            3660             MOV   D,A      * MULTIPLY (HL) BY 31
2CC3 7D            3670             MOV   A,L      *  IE. HL=(HL)*32-(HL)
2CC4 2F            3680             CMA
2CC5 5F            3690             MOV   E,A
2CC6 13            3700             INX   D
2CC7 29            3710             DAD   H
2CC8 29            3720             DAD   H
2CC9 29            3730             DAD   H
2CCA 29            3740             DAD   H
2CCB 29            3750             DAD   H
2CCC 19            3760             DAD   D
2CCD 11 58 01      3770             LXI   D,8*43   * ADD 43 SHIFTED 3 LEFT
2CD0 19            3780             DAD   D
2CD1 7C            3790             MOV   A,H      * NEW F0 VALUE INTO A
2CD2 D1            3800             POP   D        * GET BUFFER PTR
2CD3 E5            3810             PUSH  H
2CD4 21 09 00      3820             LXI   H,9
2CD7 19            3830             DAD   D        * UPDATE TO NEXT FRAME
2CD8 EB            3840             XCHG
2CD9 2A EF 36      3850             LHLD  NEGBND
2CDC 19            3860             DAD   D
2CDD DA AC 2D      3870             JC    BFERR-1  * SORRY, BUFFER IS FULL
2CE0 EB            3880             XCHG
2CE1 77            3890             MOV   M,A      * PUT F0 IN BUFFER
2CE2 0D            3900             DCR   C
2CE3 C2 B5 2C      3910             JNZ   DWN1
2CE6 D1            3920             POP   D
2CE7               3930 *
2CE7               3940 *  END F0LOOP, STEP MATRIX TO NEXT PHON
2CE7               3950 *
2CE7 22 DF 36      3960 ENDF0       SHLD  BUFPTR   * SAVE BUFFER POINTER
2CEA 2A 00 35      3970             LHLD  MATPTR
2CED 23            3980             INX   H
2CEE 22 00 35      3990             SHLD  MATPTR   * INCREMENT MATRIX POINTER
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2CF1 EB          4000            XCHG
2CF2 2A 02 35    4010            LHLD  NEGEND
2CF5 19          4020            DAD   D
2CF6 D2 5A 2B    4030            JNC   F0LOOP   * THERE'S MORE TO THIS MATRIX
2CF9 2A EB 36    4040            LHLD  NEGBUF
2CFC EB          4050            XCHG
2CFD 2A DF 36    4060            LHLD  BUFPTR
2D00 19          4070            DAD   D
2D01 EB          4080            XCHG
2D02 21 09 00    4090            LXI   H,9      * BUFFER SPACE USED /9
2D05 CD 27 20    4100            CALL  DIV      *  = OVERALL FRAME COUNT
2D08 23          4110            INX   H        * BUT THAT WAS 1 FRAME SHORT
2D09 EB          4120            XCHG
2D0A 2A 06 20    4130            LHLD  BUFADR   * PUT IT IN 1ST 2 BYTES OF BUFFER
2D0D 73          4140            MOV   M,E
2D0E 23          4150            INX   H
2D0F 72          4160            MOV   M,D
2D10 AF          4170            XRA   A
2D11 C9          4180            RET
2D12             4190 *
2D12             4200 **********
2D12             4210 *
2D12             4220 *  PARABOLA GENERATOR SUBROUTINES
2D12             4230 *
2D12             4240 *  FPARAB
2D12             4250 *  CONSTRUCT FRONT PARABOLA CURVE UP TO PEAK
2D12             4260 *  ON ENTRY: (B)=STRESS X, (C)=FRAME COUNT TO PEAK
2D12             4270 *            HL POINTS TO F0 IN LAST FRAME OF PREV PHON
2D12             4280 *
2D12 AF          4290 FPARAB     XRA   A
2D13 B9          4300            CMP   C        * RETURN IF N (FRAME COUNT) =0
2D14 C8          4310            RZ
2D15 56          4320            MOV   D,M      * GET PREV F0 INTO D
2D16 E5          4330            PUSH  H
2D17 BA          4340            CMP   D
2D18 C2 1F 2D    4350            JNZ   FPRB1    * PREV F0 WAS NON-0, USE IT
2D1B CD BF 2D    4360            CALL  GETF0    * PREV WAS 0, GET ONE FROM TABLE
2D1E 56          4370            MOV   D,M
2D1F 3E 05       4380 FPRB1      MVI   A,5      * INDEX TO 2ND COL OF TABLE
2D21 CD BF 2D    4390            CALL  GETF0    * GET F0 LEVEL AT PARAB PEAK
2D24 7E          4400            MOV   A,M
2D25 92          4410            SUB   D
2D26 47          4420            MOV   B,A
2D27 21 E5 36    4430            LXI   H,HF0+1  * SET HF0 TO STARTING PT
2D2A 72          4440            MOV   M,D
2D2B 57          4450            MOV   D,A
2D2C 69          4460            MOV   L,C
2D2D 2C          4470            INR   L
2D2E AF          4480            XRA   A
2D2F 5F          4490            MOV   E,A
2D30 67          4500            MOV   H,A
2D31 CD 27 20    4510            CALL  DIV
2D34 29          4520            DAD   H        * DELTA=2*((256*DIF)/(N+1))
2D35 59          4530            MOV   E,C      * MOVE FRAME COUNT TO E
2D36 22 E7 36    4540 PARAB2     SHLD  DELTA
2D39 60          4550            MOV   H,B      * MOVE B & C OUT OF MUL'S WAY
2D3A 69          4560            MOV   L,C
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2D3B 43             4570              MOV   B,E      * GET EITHER N OR N-1 FROM E
2D3C 04             4580              INR   B
2D3D CD 24 20       4590              CALL  MUL      * DENOM=(B)*((B)-1)
2D40 4D             4600              MOV   C,L
2D41 EB             4610              XCHG
2D42 1E 00          4620              MVI   E,0
2D44 CD 27 20       4630              CALL  DIV      * S=2*((256*DIF)/DENOM)
2D47 29             4640              DAD   H
2D48 7C             4650              MOV   A,H
2D49 2F             4660              CMA
2D4A 67             4670              MOV   H,A
2D4B 7D             4680              MOV   A,L
2D4C 2F             4690              CMA
2D4D 6F             4700              MOV   L,A
2D4E 23             4710              INX   H
2D4F 22 E9 36       4720              SHLD  SD
2D52 AF             4730              XRA   A
2D53 32 E4 36       4740              STA   HF0      * CLEAR LS PART OF HF0
2D56 E1             4750              POP   H
2D57 EB             4760 PARAB3       XCHG
2D58 21 09 00       4770              LXI   H,9      * MOVE BUFFER PTR TO NEXT FRAME
2D5B 19             4780              DAD   D
2D5C EB             4790              XCHG
2D5D 2A EF 36       4800              LHLD  NEGBND
2D60 19             4810              DAD   D
2D61 DA AD 2D       4820              JC    BFERR    * RAN OUT OF ROOM!
2D64 D5             4830              PUSH  D
2D65 2A E7 36       4840              LHLD  DELTA
2D68 EB             4850              XCHG
2D69 2A E4 36       4860              LHLD  HF0
2D6C 19             4870              DAD   D
2D6D 22 E4 36       4880              SHLD  HF0      * HF0=HF0+DELTA
2D70 44             4890              MOV   B,H      * H CONTAINS NEW F0 VALUE
2D71 2A E9 36       4900              LHLD  SD
2D74 19             4910              DAD   D
2D75 22 E7 36       4920              SHLD  DELTA    * DELTA=DELTA+S
2D78 E1             4930              POP   H        * GET BUF PTR BACK
2D79 70             4940              MOV   M,B
2D7A 0D             4950              DCR   C
2D7B C2 57 2D       4960              JNZ   PARAB3
2D7E C9             4970              RET
2D7F                4980 *
2D7F                4990 *   BPARAB
2D7F                5000 *   CONSTRUCT BACK PARABOLIC CURVE DOWN FROM PEAK
2D7F                5010 *   ON ENTRY: (B)=STRESS X, (C)=FRAME CNT DOWN FROM PEAK
2D7F                5020 *              HL POINTS TO F0 PARAM AT PEAK
2D7F                5030 *.
2D7F AF             5040 BPARAB       XRA   A
2D80 B9             5050              CMP   C        * RETURN IF FRAME COUNT =0
2D81 C8             5060              RZ
2D82 56             5070              MOV   D,M      * GET PREV F0 VALUE
2D83 E5             5080              PUSH  H
2D84 3E 0A          5090              MVI   A,10
2D86 CD BF 2D       5100              CALL  GETF0    * SET HL TO END-PARAB LEVEL
2D89 7A             5110              MOV   A,D
2D8A 32 E5 36       5120              STA   HF0+1    * SAVE OLD F0
2D8D 96             5130              SUB   M
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2D8E 47          5140            MOV   B,A      * DIFF TO NEW F0 INTO B
2D8F 21 00 00    5150            LXI   H,0
2D92 59          5160            MOV   E,C
2D93 1D          5170            DCR   E
2D94 C2 36 2D    5180            JNZ   PARAB2   * N>1, COMPUTE PARABOLA
2D97 3A E5 36    5190            LDA   HF0+1    * N=1, STORE 1 POINT
2D9A 80          5200            ADD   B
2D9B D1          5210            POP   D
2D9C 21 09 00    5220            LXI   H,9      * INCR PTR TO NEXT FRAME
2D9F 19          5230            DAD   D
2DA0 EB          5240            XCHG
2DA1 2A EF 36    5250            LHLD  NEGBND
2DA4 19          5260            DAD   D
2DA5 DA AD 2D    5270            JC    BFERR    * NO MORE ROOM
2DA8 EB          5280            XCHG
2DA9 77          5290            MOV   M,A
2DAA AF          5300            XRA   A
2DAB C9          5310            RET
2DAC             5320 *
2DAC             5330 *  ERROR SUBROUTINE
2DAC             5340 *
2DAC D1          5350            POP   D        * ENTRY HERE FROM DOWNDR
2DAD 21 B3 2D    5360 BFERR      LXI   H,BFTX
2DB0 F6 FF       5370            ORI   255
2DB2 C9          5380            RET
2DB3             5390 *
2DB3 42 55 46    5400 BFTX       DT    'BUFFER FULL'
2DB6 46 45 52
2DB9 20 46 55
2DBC 4C 4C
2DBE 0D          5410            DB    0DH
2DBF             5420 *
2DBF             5430 *  GET AN F0 LEVEL FROM STRSF0 TABLE (SET HL TO IT)
2DBF             5440 *  ON ENTRY:
2DBF             5450 *   A TELLS THE COLUMN, 0=SP, 5=MP, 10=EP
2DBF             5460 *   B CONTAINS THE STRESS LEVEL 1-5
2DBF             5470 *  ON RETURN, HL POINTS TO THE DESIRED ENTRY
2DBF             5480 *
2DBF 21 C9 2D    5490 GETF0      LXI   H,STRSF0-1
2DC2 80          5500            ADD   B
2DC3 85          5510            ADD   L
2DC4 6F          5520            MOV   L,A
2DC5 3E 00       5530            MVI   A,0
2DC7 8C          5540            ADC   H
2DC8 67          5550            MOV   H,A
2DC9 C9          5560            RET
2DCA             5570 *
2DCA             5580 *  F0 TABLE FOR DIFFERENT STRESS LEVELS
2DCA             5590 *
2DCA 63          5600 STRSF0     DB    99     * PARAB STARTING PT., STRESS 1
2DCB 59          5610            DB    89     * S.P., STRESS 2
2DCC 54          5620            DB    84     *  ETC.
2DCD 52          5630            DB    82
2DCE 51          5640            DB    81
2DCF 6C          5650            DB    108    * PARAB MID POINT (PEAK)
2DD0 63          5660            DB    99
2DD1 5E          5670            DB    94
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2DD2 5C             5680             DB    92
2DD3 5B             5690             DB    91
2DD4 59             5700             DB    89    * PARAB END POINT
2DD5 4F             5710             DB    79
2DD6 4A             5720             DB    74
2DD7 47             5730             DB    71
2DD8 46             5740             DB    70
2DD9                5750 *
2DD9                5760 ***********
2DD9                5770 *
2DD9                5780 *  CLRBUF IS CALLED BY GENPRM TO INITIALIZE
2DD9                5790 *  THE PARAMETER BUFFER (OR PART OF IT)
2DD9                5900 *  VALUES IN THE F0 PARAMETER ARE NOT DISTURBED
2DD9                5810 *
2DD9                5820 *  ON ENTRY: (BC)= THE # OF FRAMES TO INITIALIZE
2DD9                5830 *              STARTING WITH THE 2ND FRAME OF THE BUFFER
2DD9                5840 *
2DD9 2A 06 20       5850 CLRBUF      LHLD  BUFADR
2DDC 11 0B 00       5860             LXI   D,11
2DDF 19             5870             DAD   D
2DE0 16 80          5880             MVI   D,128
2DE2 1E AC          5890             MVI   E,172
2DE4 AF             5900 CLOOP       XRA   A
2DE5 77             5910             MOV   M,A     * AV=0
2DE6 23             5920             INX   H
2DE7 23             5930             INX   H
2DE8 72             5940             MOV   M,D     * F1=128
2DE9 23             5950             INX   H
2DEA 72             5960             MOV   M,D     * F2=128
2DEB 23             5970             INX   H
2DEC 73             5980             MOV   M,E     * F3=172
2DED 23             5990             INX   H
2DEE 77             6000             MOV   M,A     * AH=0
2DEF 23             6010             INX   H
2DF0 77             6020             MOV   M,A     * AF=0
2DF1 23             6030             INX   H
2DF2 72             6040             MOV   M,D     * FF=128
2DF3 23             6050             INX   H
2DF4 77             6060             MOV   M,A     * AN=0
2DF5 23             6070             INX   H
2DF6 0B             6080             DCX   B
2DF7 B0             6090             ORA   B
2DF8 31             6100             ORA   C
2DF9 C2 E4 2D       6110             JNZ   CLOOP
2DFC C9             6120             RET
2DFD                6130 *
2DFD                6140 *  END OF SECT4
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2000            0010 *  GENPRM
2000            0020 *
2000            0030 *  SECTION 5 OF THE CSR1 SYNTHESIS BY RULE SYSTEM
2000            0040 *
2000            0050 *  LLOYD RICE,  COMPUTALKER CONSULTANTS
2000            0060 *  VERSION 1.08    MAY 30, 1977
2000            0070 *
2000            0080 **********
2000            0090 *
2000            0100 *  COMMON JUMP ADDRESS TABLE
2000            0110 *
2000            0120 COMJMP      EQU    $
2000            0130 *
2000            0140 CSR1        DS     3
2003            0150 PLAY        DS     3
2006            0160 BUFADR      DS     2
2008            0170 BUFLEN      DS     2
200A            0180 PVTAB       DS     2
200C            0190 MATPAR      DS     3
200F            0200 MATERR      DS     3
2012            0210 RULES       DS     3
2015            0220 SETDUR      DS     3
2018            0230 RULES3      DS     3
201B            0240 GENFC       DS     3
201E            0250 CLRBUF      DS     3
2021 C3 00 2E   0260             JMP    GENPRM
2024 C3 00 32   0270             JMP    MUL
2027 C3 13 32   0280             JMP    DIV
202A            0290 GETCNS      DS     3
202D            0300 PCBF1       DS     3
2030            0310 F1TAR       DS     2
2032            0320 F2TAR       DS     2
2034            0330 F3TAR       DS     2
2036            0340 AVHTAR      DS     2
2038            0350 FNTAR       DS     2
203A            0360 *
203A            0370 **********
203A            0380 *
203A            0390 *  COMRAM ORIGEN DEFINITION
203A            0400 *
203A            0410             ORG    COMJMP+1500H
3500            0420 COMRAM      EQU    $
3500            0430 *
3500            0440 *  CSR1 SYSTEM RAM SPACE DEFINITION
3500            0450 *
3500            0460 MATPTR      DS     2
3502            0470 REGEND      DS     2
3504            0480 MATRIX      EQU    $
3504            0490 MATLEN      EQU    95
3504            0500 PHCODE      DS     MATLEN
3563            0510 FEATA       DS     MATLEN
35C2            0520 FEATB       DS     MATLEN
3621            0530 STRES       DS     MATLEN
3680            0540 DUR         DS     MATLEN
36DF            0550 MATEND      EQU    $
36DF            0560 BUFPTR      DS     2
36E1            0570 *
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

36E1            0580 *  THE NEXT 19 LOCATIONS ARE ACCESSED BY ROUTINES
36E1            0590 *  IN SECTION 6 AND MUST NOT BE MOVED
36E1            0600 *
36E1            0610 OCODE       DS    1
36E2            0620 OFEATA      DS    1
36E3            0630 OFEATB      DS    1
36E4            0640 ODUR        DS    1
36E5            0650 OCID        DS    1
36E6            0660 ORANK       DS    1
36E7            0670 OPCT        DS    1
36E8            0680 OTIMES      DS    1
36E9            0690 *
36E9            0700 CODEX       DS    1
36EA            0710 FEATAX      DS    1
36EB            0720 FEATBX      DS    1
36EC            0730 DURX        DS    1
36ED            0740 CIDX        DS    1
36EE            0750 RANKX       DS.   1
36EF            0760 PCTX        DS    1
36F0            0770 TIMESX      DS    1
36F1            0780 *
36F1            0790 BT          DS    1
36F2            0800 FT          DS    1
36F3            0810 FC          DS    1
36F4            0820 *
36F4            0830 *  GENPRM (LOCAL) RAM WORKSPACE
36F4            0840 *
36F4            0850 TARG        DS    1
36F5            0860 BVAL        DS    1
36F6            0870 SD          DS    2
36F8            0880 DELTA       DS    2
36FA            0890 PCOUNT      DS    1
36FB            0900 NTARGS      DS    1
36FC            0910 ASPT        DS    1
36FD            0920 *
36FD            0930 **********
36FD            0940 *
36FD            0950 *  GENPRM
36FD            0960 *
36FD            0970             ORG   COMJMP+0E00H
2E00            0980 SECTAD      EQU   $
2E00            0990 *
2E00            1000 **********
2E00            1010 *
2E00            1020 *  PHONEME CODE DEFINITIONS
2E00            1030 *
2E00            1040 CTERM       EQU   4
2E00            1050 CP          EQU   39
2E00            1060 *
2E00            1070 *  FEATURE LABEL DEFINITIONS
2E00            1080 *
2E00            1090 IGNORE      EQU   1
2E00            1100 STOP        EQU   30H
2E00            1110 PLOS        EQU   20H
2E00            1120 PLOSA       EQU   10H
2E00            1130 *
2E00            1140 *  OUTPUT CHANNEL DEFINITIONS
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2E00              1150 *
2E00              1160 CHANAV      EQU   0
2E00              1170 CHANF1      EQU   2
2E00              1180 CHANF2      EQU   3
2E00              1190 CHANF3      EQU   4
2E00              1200 CHANAH      EQU   5
2E00              1210 CHANAF      EQU   6
2E00              1220 CHANFF      EQU   7
2E00              1230 CHANAN      EQU   8
2E00              1240 *
2E00              1250 **********
2E00              1260 *
2E00              1270 *  GENPRM SUBROUTINE
2E00              1280 *
2E00 21 05 35     1290 GENPRM      LXI   H,MATRIX+1
2E03 22 00 35     1300             SHLD  MATPTR  * SET MATPTR TO COL 2 (SKIP #)
2E06 11 E1 36     1310             LXI   D,OCODE
2E09 CD 2A 20     1320             CALL  GETCNS  * GET CONSTANTS FOR COL 2 PAUSE
2E0C 3A E4 36     1330             LDA   ODUR
2E0F 4F           1340             MOV   C,A
2E10 06 00        1350             MVI   B,0
2E12 CD 1E 20     1360             CALL  CLRBUF  * INITIALIZE THE 1ST FRAME
2E15 11 F7 FF     1370             LXI   D,-9
2E18 19           1380             DAD   D
2E19 22 DF 36     1390             SHLD  BUFPTR  * SET BUFPTR TO LAST FRAME AV
2E1C 21 06 35     1400             LXI   H,MATRIX+2
2E1F 22 00 35     1410             SHLD  MATPTR  * MATPTR PTS TO 1ST ACTUAL PHON
2E22              1420 *
2E22              1430 *
2E22              1440 *  DURING PROCESSING FOR EACH PHON, MATPTR INDICATES
2E22              1450 *  THE CURRENT MATRIX COLUMN.  BUFPTR IS THE PARAMETER
2E22              1460 *  BUFFER INDEX.  IT CONTAINS THE ADDRESS OF THE AV
2E22              1470 *  PARAMETER IN THE LAST FRAME OF THE PREVIOUSLY
2E22              1480 *  PROCESSED PHON.
2E22              1490 *
2E22 11 E9 36     1500 GPLOOP      LXI   D,CODEX
2E25 CD 2A 20     1510             CALL  GETCNS  * GET CONSTANTS FOR NEXT PHON
2E28 3A EA 36     1520             LDA   FEATAX
2E2B E6 01        1530             ANI   IGNORE
2E2D C2 7C 30     1540             JNZ   ENDPRM  * IGNORE THIS MATRIX COLUMN
2E30 3A E3 36     1550             LDA   CFEATB
2E33 E6 20        1560             ANI   PLOS
2E35 CA 40 2E     1570             JZ    NOPLOS  * THE PRECEEDING WAS NOT A PLOSIV
2E38 3A EB 36     1580             LDA   FEATBX  * PREVIOUS WAS PLOSIVE
2E3B E6 80        1590             ANI   STOP
2E3D CA 30 2F     1600             JZ    SETASP  * CURR IS -STOP, SET ASPIRATION
2E40              1610 *
2E40              1620 *  NOPLOS IS THE MAIN GENERATOR LOOP FOR MOST
2E40              1630 *  PHON SEQUENCES.
2E40              1640 *  FORMANT TRANSITIONS ARE GOVERNED BY RELATIVE RANKS
2E40              1650 *
2E40 3A EE 36     1660 NOPLOS      LDA   RANKX   * COMPARE RANKS OF CURRENT
2E43 47           1670             MOV   B,A
2E44 3A E6 36     1680             LDA   ORANK   *    AND PREVIOUS PHONS
2E47 B8           1690             CMP   B
2E48 CA 6D 2E     1700             JZ    EQRANK  * RANKS ARE EQUAL
2E4B DA 85 2E     1710             JC    OLTCUR  * OLD LESS THAN CURRENT
```

```
ADDR B1 B2 B3 E LINE  LABEL      CPCD  OPERAND

2E4E 3A E8 36    1720              LDA   OTIMES   * OLD GREATER THAN CURRENT
2E51 6F          1730              MOV   L,A
2E52 E6 0F       1740              ANI   0FH
2E54 32 F1 36    1750              STA   BT       * BACK TIME = OLD TPRI
2E57 26 00       1760              MVI   H,0
2E59 29          1770              DAD   H
2E5A 29          1780              DAD   H
2E5B 29          1790              DAD   H
2E5C 29          1800              DAD   H
2E5D 7C          1810              MOV   A,H
2E5E 32 F2 36    1820              STA   FT       * FORWARD TIME = OLD TSEC
2E61 3A E7 36    1830              LDA   OPCT
2E64 2F          1840              CMA
2E65 C6 05       1850              ADI   5
2E67 32 F3 36    1860              STA   PC       * PC=1.0-OPCT(BN PT RT OF BIT 2)
2E6A C3 9E 2E    1870              JMP   SETFOR
2E6D             1880 *
2E6D 3A E8 36    1890 EQRANK       LDA   OTIMES
2E70 E6 0F       1900              ANI   0FH
2E72 32 F1 36    1910              STA   BT       * BACK TIME = OLD TPRI
2E75 3A FC 36    1920              LDA   TIMESX
2E78 E6 0F       1930              ANI   0FH
2E7A 32 F2 36    1940              STA   FT       * FORWARD TIME = CURR TPRI
2E7D 3E 02       1950              MVI   A,2
2E7F 32 F3 36    1960              STA   PC       * PC=.5 (BIN PT RIGHT OF BIT 2)
2E82 C3 9E 2E    1970              JMP   SETFOR
2E85             1980 *
2E85 3A FC 36    1990 OLTCUR       LDA   TIMESX
2E88 6F          2000              MOV   L,A
2E89 E6 0F       2010              ANI   0FH
2E8B 32 F2 36    2020              STA   FT       * FORWARD TIME = CURR TPRI
2E8E 26 00       2030              MVI   H,0
2E90 29          2040              DAD   H
2E91 29          2050              DAD   H
2E92 29          2060              DAD   H
2E93 29          2070              DAD   H
2E94 7C          2080              MOV   A,H
2E95 32 F1 36    2090              STA   BT       * BACK TIME = CURR TSEC
2E98 3A EF 36    2100              LDA   PCTX
2E9B 32 F3 36    2110              STA   PC       * PC = CURRENT PCT
2E9E             2120 *
2E9E             2130 *   COMPUTE & STORE 3 FORMANT PARAMETERS
2E9E             2140 *
2E9E 2A 30 20    2150 SETFOR       LHLD  F1TAR
2EA1 EB          2160              XCHG
2EA2 01 02 00    2170              LXI   B,CHANF1
2EA5 CD AE 30    2180              CALL  GENFX    * SET FORMANT 1
2EA8 2A 32 20    2190              LHLD  F2TAR
2EAB EB          2200              XCHG
2EAC 01 03 00    2210              LXI   B,CHANF2
2EAF CD AE 30    2220              CALL  GENFX    * SET FORMANT 2
2EB2 2A 34 20    2230              LHLD  F3TAR
2EB5 EB          2240              XCHG
2EB6 01 04 00    2250              LXI   B,CHANF3
2EB9 CD AE 30    2260              CALL  GENFX    * SET FORMANT 3
2EBC             2270 *
2EBC             2280 *   COMPUTE & STORE AV
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2EBC            2290 *
2EBC 06 00      2300 SETAMP     MVI   B,0
2EBE CD 2D 20   2310            CALL  PCBFT     * SETUP PC,BT & FT WITH AV INFO
2EC1 2A 36 20   2320            LHLD  AVHTAR
2EC4 3A E9 36   2330            LDA   CODEX
2EC7 16 00      2340            MVI   D,0
2EC9 5F         2350            MOV   E,A
2ECA 19         2360            DAD   D
2ECB 7E         2370            MOV   A,M       * GET AV/AH TARGET BYTE
2ECC F5         2380            PUSH  PSW
2ECD E6 F0      2390            ANI   0F0H      * MASK TO KEEP AV
2ECF 01 00 00   2400            LXI   B,CHANAV
2ED2 CD C6 30   2410            CALL  GENAX     * SET AMPLITUDE OF VOICING
2ED5            2420 *
2ED5            2430 *  COMPUTE & STORE AH
2ED5            2440 *
2ED5 F1         2450            POP   PSW
2ED6 E6 0F      2460            ANI   0FH       * NOW MASK TO KEEP AH
2ED8 87         2470            ADD   A
2ED9 87         2480            ADD   A         * MULT BY 4
2EDA 01 05 00   2490            LXI   B,CHANAH
2EDD CD C6 30   2500            CALL  GENAX     * SET AMPLITUDE OF HISS
2EE0            2510 *
2EE0            2520 *  COMPUTE & STORE AF
2EE0            2530 *
2EE0 06 01      2540            MVI   B,1
2EE2 CD 2D 20   2550            CALL  PCBFT     * SET PC, BT & FT WITH AF INFO
2EE5 2A 38 20   2560            LHLD  FRNTAR
2EE8 3A E9 36   2570            LDA   CODEX
2EEB 5F         2580            MOV   E,A
2EEC 16 00      2590            MVI   D,0
2EEE 19         2600            DAD   D
2EEF 7E         2610            MOV   A,M       * GET FRIC/NASAL TARGET BYTE
2EF0 F5         2620            PUSH  PSW
2EF1 E6 1C      2630            ANI   1CH       * MASK TO KEEP AF TARGET
2EF3 87         2640            ADD   A
2EF4 01 06 00   2650            LXI   B,CHANAF
2EF7 CD C6 30   2660            CALL  GENAX     * SET AMPLITUDE OF FRICATION
2EFA            2670 *
2EFA            2680 *  SET FF TO TARGET VALUE FOR TIME DURX
2EFA            2690 *
2EFA F1         2700            POP   PSW       * GET FRIC TARC AGAIN
2EFB 3B         2710            DCX   SP
2EFC 3B         2720            DCX   SP        * BUT LEAVE IT IN THE STACK, TOO
2EFD E6 E0      2730            ANI   0E0H      * KEEP FF TARGET
2EFF 57         2740            MOV   D,A
2F00 01 07 00   2750            LXI   B,CHANFF
2F03 2A DF 36   2760            LHLD  BUFPTR
2F06 09         2770            DAD   B
2F07 3A EC 36   2780            LDA   DURX
2F0A 01 09 00   2790            LXI   B,9
2F0D 09         2800 SETFF      DAD   B
2F0E 72         2810            MOV   M,D       * SET FF DIRECTLY FROM TARGET
2F0F 3D         2820            DCR   A
2F10 C2 0D 2F   2830            JNZ   SETFF
2F13            2840 *
2F13            2850 *  COMPUTE & STORE AN
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2F13            2860 *
2F13 3E 03      2870            MVI   A,3       * PC=.5 FOR NASAL
2F15 32 F3 36   2880            STA   PC
2F18 3D         2890            DCR   A
2F19 32 F1 36   2900            STA   BT        * BACK & FORW TIMES = 2 FRAMES
2F1C 32 F2 36   2910            STA   FT
2F1F F1         2920            POP   PSW       * GET NASAL TARGET
2F20 E6 03      2930            ANI   3
2F22 87         2940            ADD   A
2F23 87         2950            ADD   A
2F24 87         2960            ADD   A
2F25 87         2970            ADD   A
2F26 87         2980            ADD   A         * MULT BY 32
2F27 01 08 00   2990            LXI   B,CHANAN
2F2A CD C8 30   3000            CALL  GENAX     * SET AMPLITUDE OF NASAL
2F2D C3 7C 30   3010            JMP   ENDPRM
2F30            3020 *
2F30            3030 *
2F30            3040 *  HANDLE -STOP AFTER PLOSIVE
2F30            3050 *  SETASP SETS THE PLOSIVE BURST PULSE
2F30            3060 *  AND IF NEEDED, ASPIRATION IN THE FOLLOWING PHON.
2F30            3070 *
2F30 3A E1 36   3080 SETASP     LDA   OCODE
2F33 D6 27      3090            SUI   CP
2F35 4F         3100            MOV   C,A       * PLOSIVE CODE - CODE OF "P"
2F36 06 00      3110            MVI   B,0
2F38 21 38 32   3120            LXI   H,PLOSC * MAKE POINTER TO PLOSC TABLE
2F3B 09         3130            DAD   B
2F3C 7E         3140            MOV   A,M       * GET LENGTH OF BURST PULSE
2F3D 47         3150            MOV   B,A
2F3E 87         3160            ADD   A
2F3F 87         3170            ADD   A
2F40 87         3180            ADD   A
2F41 80         3190            ADD   B
2F42 2F         3200            CMA
2F43 3C         3210            INR   A
2F44 4F         3220            MOV   C,A
2F45 78         3230            MOV   A,B       * A = PULSE LENGTH
2F46 06 FF      3240            MVI   B,255     * BC = -9*(PULSE LENGTH)
2F48 2A DF 36   3250            LHLD  BUFPTR
2F4B 09         3260            DAD   B
2F4C 01 06 00   3270            LXI   B,CHANAF
2F4F 09         3280            DAD   B
2F50 01 09 00   3290            LXI   B,9
2F53 09         3300 BURST      DAD   B
2F54 36 24      3310            MVI   M,36      * PLOSIVE BURST AF VALUE
2F56 3D         3320            DCR   A
2F57 C2 53 2F   3330            JNZ   BURST
2F5A            3340 *
2F5A            3350 *  COMPUTE FORMANTS FOR PHON AFTER PLOSIVE
2F5A            3360 *
2F5A 3A EE 36   3370            LDA   RANKX
2F5D FE 03      3380            CPI   3
2F5F D2 71 2F   3390            JNC   GTPLOS    * CURR RANK > PLOS RANK (=2)
2F62 3E 02      3400            MVI   A,2
2F64 32 F3 36   3410            STA   PC        * CURR RANK <= 2, PC=0.5
2F67 3A E8 36   3420            LDA   OTIMES    * FT = OLD 1SEC
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2F6A 0F            3430            RRC
2F6B 0F            3440            RRC
2F6C 0F            3450            RRC
2F6D 0F            3460            RRC
2F6E C3 7A 2F      3470            JMP   SETIMS
2F71               3480 *
2F71 3A EF 36      3490 GTPLOS     LDA   PCTX
2F74 32 F3 36      3500            STA   PC        * PC = PCT OF CURRENT PHON
2F77 3A F0 36      3510            LDA   TIMESX    * FT = CURR. TPRI
2F7A E6 0F         3520 SETIMS     ANI   0FH
2F7C 32 F2 36      3530            STA   FT
2F7F 3E 01         3540            MVI   A,1
2F81 32 F1 36      3550            STA   BT        * BACK TIME = 1 (TO SET BVAL)
2F84               3560 *
2F84               3570 *  GENERATE FORMANTS DURING ENTIRE POST-PLOSIVE
2F84               3580 *
2F84 2A 30 20      3590            LHLD  F1TAR
2F87 EB            3600            XCHG
2F88 01 02 00      3610            LXI   B,CHANF1
2F8B CD AE 30      3620            CALL  GENFX     * SET FORMANT 1
2F8E 2A 32 20      3630            LHLD  F2TAR
2F91 EB            3640            XCHG
2F92 01 03 00      3650            LXI   B,CHANF2
2F95 CD AE 30      3660            CALL  GENFX     * SET FORMANT 2
2F98 2A 34 20      3670            LHLD  F3TAR
2F9B EB            3680            XCHG
2F9C 01 04 00      3690            LXI   B,CHANF3
2F9F CD AE 30      3700            CALL  GENFX     * SET FORMANT 3
2FA2               3710 *
2FA2               3720 *  SET FF = TARGET VALUE FOR TIME DURX
2FA2               3730 *
2FA2 2A 38 20      3740            LHLD  FRNTAR
2FA5 3A E9 36      3750            LDA   CODEX
2FA8 5F            3760            MOV   E,A
2FA9 16 00         3770            MVI   D,0
2FAB 19            3780            DAD   D
2FAC 7E            3790            MOV   A,M       * GET PHON X FRICATIVE TARGET
2FAD E6 E0         3800            ANI   0E0H      * MASK TO KEEP FF
2FAF 57            3810            MOV   D,A
2FB0 2A DF 36      3820            LHLD  BUFPTR
2FB3 01 07 00      3830            LXI   B,CHANFF
2FB6 09            3840            DAD   B
2FB7 3A EC 36      3850            LDA   DURX
2FBA 01 09 00      3860            LXI   B,9
2FBD 09            3870 SETFF2     DAD   B
2FBE 72            3880            MOV   M,D       * SET FF DIRECTLY FROM TARGET
2FBF 3D            3890            DCR   A
2FC0 C2 BD 2F      3900            JNZ   SETFF2
2FC3               3910 *
2FC3               3920 *  SET AN=0 FOR TIME DURX
2FC3               3930 *
2FC3 2A DF 36      3940            LHLD  BUFPTR
2FC6 11 08 00      3950            LXI   D,CHANAN
2FC9 19            3960            DAD   D
2FCA 3A EC 36      3970            LDA   DURX
2FCD 09            3980 SETAN      DAD   B
2FCE 36 00         3990            MVI   M,0       * SET AN = 0
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

2FD0 3D          4000             DCR   A
2FD1 C2 CD 2F    4010             JNZ   SETAN
2FD4             4020 *
2FD4             4030 *  SEE IF PLOSIVE SHOULD BE ASPIRATED
2FD4             4040 *
2FD4 3A E3 36    4050             LDA   OFEATB
2FD7 E6 10       4060             ANI   PLOSA
2FD9 CA 3A 30    4070             JZ    FINASP     * NO, FINISH CURR. PHON
2FDC 3A EC 36    4080             LDA   DURX
2FDF 16 05       4090             MVI   D,5        * BASE ASP TIME = 50 MSEC
2FE1 BA          4100             CMP   D
2FE2 DA E6 2F    4110             JC    $+4        * DURX < 50 MSEC, SET ASPT=DURX
2FE5 7A          4120             MOV   A,D        * THERE'S ROOM, SET ASPT=50 MSEC
2FE6 32 FC 36    4130             STA   ASPT
2FE9             4140 *
2FE9             4150 *  SET AV = 0 FOR DURATION OF ASPIRATION (ASPT)
2FE9             4160 *
2FE9 2A DF 36    4170             LHLD  BUFPTR
2FEC 11 00 00    4180             LXI   D,CHANAV
2FEF 19          4190             DAD   D
2FF0 09          4200 SETAV       DAD   B
2FF1 36 00       4210             MVI   M,0        * SET AV = 0
2FF3 3D          4220             DCR   A
2FF4 C2 F0 2F    4230             JNZ   SETAV
2FF7             4240 *
2FF7             4250 *  SET AF = 0 DURING ASPIRATION
2FF7             4260 *
2FF7 3A FC 36    4270             LDA   ASPT
2FFA 2A DF 36    4280             LHLD  BUFPTR
2FFD 11 06 00    4290             LXI   D,CHANAF
3000 19          4300             DAD   D
3001 09          4310 SETAF       DAD   B
3002 36 00       4320             MVI   M,0        * SET AF = 0
3004 3D          4330             DCR   A
3005 C2 01 30    4340             JNZ   SETAF
3008             4350 *
3008             4360 *  CALL FRWRD TO PRODUCE TRANSIENT PULSE ON AH
3008             4370 *
3008 AF          4380             XRA   A
3009 32 F4 36    4390             STA   TARG
300C 3A FC 36    4400             LDA   ASPT
300F 47          4410             MOV   B,A        * DECAY TO 0 BY END OF ASP TIME
3010 4F          4420             MOV   C,A
3011 2A DF 36    4430             LHLD  BUFPTR
3014 11 05 00    4440             LXI   D,CHANAH
3017 19          4450             DAD   D
3018 36 32       4460             MVI   M,50       * INITIAL AH PULSE AMPLITUDE
301A CD E7 30    4470             CALL  FRWRD
301D             4480 *
301D             4490 *  SEE IF ASPIRATION TIME TOOK THE ENTIRE CURR. PHON
301D             4500 *
301D 3A FC 36    4510             LDA   ASPT
3020 47          4520             MOV   B,A
3021 3A EC 36    4530             LDA   DURX
3024 90          4540             SUB   B
3025 CA 7C 30    4550             JZ    ENDPRM     * ASP TIME TOOK IT ALL, DONE
3028 32 EC 36    4560             STA   DURX       * SET DURX=DURX-ASPT
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

3028 78          4570           MOV   A,E
302C 87          4580           ADD   A
302D 87          4590           ADD   A
302E 87          4600           ADD   A
302F 80          4610           ADD   B
3030 4F          4620           MOV   C,A      * ASPT*9 INTO BC
3031 06 00       4630           MVI   B,0
3033 2A DF 36    4640           LHLD  BUFPTR
3036 09          4650           DAD   B
3037 22 DF 36    4660           SHLD  BUFPTR   * BUFPTR=BUFPTR+9*ASPT
303A             4670 *
303A             4680 *  COMPUTE AV FOR REMAINDER OF PHON
303A             4690 *
303A 06 00       4700 FINASP    MVI   B,0
303C CD 2D 20    4710           CALL  PCBFT    * GET AV/AH VALUES FOR PC & FT
303F 3E 01       4720           MVI   A,1
3041 32 F1 36    4730           STA   BT       * BT=1 SETS BVAL FROM TARG
3044 2A 36 20    4740           LHLD  AVHTAR
3047 3A E9 36    4750           LDA   CODEX
304A 16 00       4760           MVI   D,0
304C 5F          4770           MOV   E,A
304D 19          4780           DAD   D
304E D5          4790           PUSH  D        * SAVE CODEX TABLE OFFSET
304F 7E          4800           MOV   A,M      * GET AV/AH TARGET BYTE
3050 F5          4810           PUSH  PSW      * SAVE IT
3051 E6 F0       4820           ANI   0F0H     * MASK TO KEEP AV
3053 01 00 00    4830           LXI   B,CHANAV
3056 CD C8 30    4840           CALL  GENAX    * FINISH AV CURVE
3059             4850 *
3059             4860 *  COMPUTE AH FOR REMAINDER OF PHON
3059             4870 *
3059 F1          4880           POP   PSW
305A E6 0F       4890           ANI   0FH      * MASK TARGET BYTE TO KEEP AH
305C 87          4900           ADD   A
305D 87          4910           ADD   A        * MULT BY 4
305E 01 05 00    4920           LXI   B,CHANAH
3061 CD C8 30    4930           CALL  GENAX    * FINISH AH CURVE
3064             4940 *
3064             4950 *  COMPUTE AF FOR REMAINDER OF PHON
3064             4960 *
3064 3E 03       4970           MVI   A,3
3066 32 F2 36    4980           STA   FT       * FT = 3
3069 3C          4990           INR   A
306A 32 F3 36    5000           STA   PC       * PC = 1.00
306D 2A 38 20    5010           LHLD  FRNTAR
3070 D1          5020           POP   D
3071 19          5030           DAD   D
3072 7E          5040           MOV   A,M      * GET FRIC/NASAL TARGET BYTE
3073 E6 1C       5050           ANI   1CH      * MASK TO KEEP AF
3075 87          5060           ADD   A
3076 01 06 00    5070           LXI   B,CHANAF
3079 CD C8 30    5080           CALL  GENAX    * FINISH AF CURVE
307C             5090 *
307C             5100 *
307C 00          5110 ENDPRM    NOP   *        * BREAKPOINT LOC
307D 2A EC 36    5120           LHLD  DURX
3080 26 00       5130           MVI   H,0
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

3082 54            5140             MOV   D,H
3083 5D            5150             MOV   E,L      * MULTIPLY DURX BY 9
3084 29            5160             DAD   H
3085 29            5170             DAD   H
3086 29            5180             DAD   H
3087 19            5190             DAD   D
3088 EB            5200             XCHG
3089 2A DF 36      5210             LHLD  BUFPTR
308C 19            5220             DAD   D
308D 22 DF 36      5230             SHLD  BUFPTR   * BUFPTR=BUFPTR+9*DURX
3090 21 E9 36      5240             LXI   H,CODEX
3093 11 E1 36      5250             LXI   D,OCODE
3096 0E 08         5260             MVI   C,8
3098 7E            5270 CNSLP       MOV   A,M      * MOVE CURR CONSTANT VALUES
3099 12            5280             STAX  D        * INTO OLD CONSTANTS
309A 23            5290             INX   H
309B 13            5300             INX   D
309C 0D            5310             DCR   C
309D C2 98 30      5320             JNZ   CNSLP
30A0 2A 0C 35      5330             LHLD  MATPTR
30A3 23            5340             INX   H
30A4 22 0C 35      5350             SHLD  MATPTR
30A7 7E            5360             MOV   A,M
30A8 FE 04         5370             CPI   CTERM    * SEE IF NEW CODE IS TERMINATOR
30AA C2 22 2E      5380             JNZ   GPLOOP   * NO, DO ANOTHER COLUMN
30AD C9            5390             RET   *        * THAT'S IT, LETS GO LISTEN
30AE               5400 *
30AE               5410 *
30AE               5420 **********
30AE               5430 *
30AE               5440 *  GENPRM SUBROUTINES AND SOME TABLES
30AE               5450 *
30AE               5460 **********
30AE               5470 *
30AE               5480 *  GENERATE FORMANT TRANSITIONS BETWEEN PREVIOUS
30AE               5490 *  AND CURRENT PHONS
30AE               5500 *  ON ENTRY:   DE POINTS TO FORMANT TARGET TABLE
30AE               5510 *              BC CONTAINS THE OUTPUT CHAN NO OF THAT
30AE               5520 *                 FORMANT (TELLS WHICH BYTE OF FRAME)
30AE               5530 *
30AE 3A E9 36      5540 GENFX       LDA   CODEX
30B1 6F            5550             MOV   L,A
30B2 26 00         5560             MVI   H,0
30B4 19            5570             DAD   D
30B5 7E            5580             MOV   A,M
30B6 32 F4 36      5590             STA   TARG     * SET TARGET VALUE
30B9 2A DF 36      5600             LHLD  BUFPTR
30BC 09            5610             DAD   B        * SET HL TO FORMANT, FRAME I
30BD 96            5620             SUB   M
30BE CD D2 31      5630             CALL  MULPC    * MULT TARG-FX(I) BY PC
30C1 86            5640             ADD   M
30C2 32 F5 36      5650             STA   BVAL     * BVAL=FX(I)+PC*(TARG-FX(I))
30C5 C3 D8 30      5660             JMP   GENBF
30C8               5670 *
30C8               5680 *  GENAX SUBROUTINE
30C8               5690 *  GENERATE AMPLITUDE TRANSITIONS BETWEEN PREV
30C8               5700 *  AND CURRENT PHONS
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

30C8              5710 *  ON ENTRY:  A CONTAINS THE PARAM TARGET VALUE
30C8              5720 *             BC CONTAINS THE OUTPUT CHAN NO.
30C8              5730 *
30C8 32 F4 36     5740 GENAX        STA   TARG      * SET TARGET VALUE
30CB 2A CF 36     5750              LHLD  BUFPTR
30CE 09           5760              DAD   B         * SET HL TO PARAM IN FRAME 1
30CF 86           5770              ADD   M
30D0 1F           5780              RAR
30D1 B7           5790              ORA   A         * DIVIDE BY 2, CLEAR CARRY
30D2 CD D2 31     5800              CALL  MULPC
30D5 32 F5 36     5810              STA   BVAL      * BVAL=PC*(TARG+Y)/2
30D8 3A F1 36     5820 GENBF        LDA   BT
30DB 47           5830              MOV   B,A
30DC CD 0B 31     5840              CALL  BCWRD     * MODIFY CURVE BACK FROM BOUNDARY
30DF 3A EC 36     5850              LDA   DURX
30E2 4F           5860              MOV   C,A
30E3 3A F2 36     5870              LDA   FT
30E6 47           5880              MOV   B,A
30E7              5890 *
30E7              5900 *  FRWRD
30E7              5910 *  STORES THE NEXT N FRAMES BEYOND THE PARAM VALUE
30E7              5920 *  CURRENTLY INDICATED BY HL.  B CONTAINS THE NUMBER
30E7              5930 *  OF FRAMES NEEDED TO REACH THE VALUE IN LOC TARG.
30E7              5940 *  C CONTAINS THE TOTAL NO. OF NEW FRAMES TO BE
30E7              5950 *  STORED.  B MAY BE ANY SIZE RELATIVE TO C
30E7              5960 *
30E7 AF           5970 FRWRD        XRA   A
30E8 B9           5980              CMP   C         * RETURN IF NOTHING TO STORE
30E9 C8           5990              RZ
30EA 3C           6000              INR   A
30EB B8           6010              CMP   B
30EC D2 5E 31     6020              JNC   SETARG    * B<=1, SET PARAM=TARG
30EF 79           6030              MOV   A,C
30F0 90           6040              SUB   B
30F1 F2 F8 30     6050              JP    FINPB     * POS # OF TARGS AFTER PARABOLA
30F4 AF           6060              XRA   A
30F5 C3 FB 30     6070              JMP   DOPB
30F8 48           6080 FINPB        MOV   C,B
30F9 0D           6090              DCR   C
30FA 3C           6100              INR   A
30FB 32 FB 36     6110 DOPB         STA   NTARGS    * SET FOR N TARGS AFTER PARAB.
30FE 79           6120              MOV   A,C
30FF 32 FA 36     6130              STA   PCOUNT    * SET # OF PARABOLA POINTS
3102 4E           6140              MOV   C,M       * GET PREV PARAM INTO C
3103 E5           6150              PUSH  H
3104 3A F4 36     6160              LDA   TARG
3107 91           6170              SUB   C
3108 F5           6180              PUSH  PSW
3109 D2 0E 31     6190              JNC   $+5
310C 2F           6200              CMA
310D 3C           6210              INR   A
310E 57           6220              MOV   D,A       * ABS(TARG-PREV) INTO D
310F 68           6230              MOV   L,B
3110 2C           6240              INR   L
3111 AF           6250              XRA   A
3112 67           6260              MOV   H,A       * HL=N+1 (N IS DIST TO PEAK)
3113 5F           6270              MOV   E,A
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

3114 CD 13 32    6280            CALL  DIV      * ABS(256*(TARG-PREV)/(N+1))
3117 29          6290            DAD   H
3118 54          6300            MOV   D,H      * SAVE ASB(DELTA)=2*QUOTIENT
3119 5D          6310            MOV   E,L
311A F1          6320            POP   PSW
311B D2 26 31    6330            JNC   FRW2
311E 7C          6340            MOV   A,H
311F 2F          6350            CMA
3120 67          6360            MOV   H,A
3121 7D          6370            MOV   A,L
3122 2F          6380            CMA
3123 6F          6390            MOV   L,A
3124 23          6400            INX   H        * FIX SIGN OF DELTA
3125 37          6410            STC
3126 E5          6420 FRW2       PUSH  H        * AND SAVE IT
3127 F5          6430            PUSH  PSW      * AND ITS SIGN
3128 68          6440            MOV   L,B
3129 26 00       6450            MVI   H,0
312B CD 13 32    6460            CALL  DIV      * COMPUTE ABS(DELTA/N)
312E F1          6470            POP   PSW
312F DA 39 31    6480            JC    FRW3
3132 7C          6490            MOV   A,H
3133 2F          6500            CMA
3134 67          6510            MOV   H,A
3135 7D          6520            MOV   A,L
3136 2F          6530            CMA
3137 6F          6540            MOV   L,A
3138 23          6550            INX   H
3139 22 F6 36    6560 FRW3       SHLD  SD       * SECOND DIFF = -DELTA/N
313C E1          6570            POP   H        * GET DELTA INTO HL
313D 51          6580            MOV   D,C      * PREV PARAM TO DE
313E 1E 00       6590            MVI   E,0
3140 3A FA 36    6600            LDA   PCOUNT   * AND PARAB COUNT TO A
3143 44          6610 FWDLP      MOV   B,H
3144 4D          6620            MOV   C,L
3145 19          6630            DAD   D
3146 D1          6640            POP   D
3147 E5          6650            PUSH  H        * Y=Y+DELTA
3148 21 09 00    6660            LXI   H,9
314B 19          6670            DAD   D
314C D1          6680            POP   D
314D E5          6690            PUSH  H        * ADDR=ADDR+9
314E 72          6700            MOV   M,D      * STORE NEW Y VALUE
314F 2A F6 36    6710            LHLD  SD
3152 09          6720            DAD   B        * DELTA=DELTA+SD
3153 3D          6730            DCR   A
3154 C2 43 31    6740            JNZ   FWDLP
3157 E1          6750            POP   H        * GET ADDR POINTER
3158 3A FB 36    6760            LDA   NTARGS   * NO. OF TARG VALUES TO WRITE
315B B7          6770            ORA   A
315C C8          6780            RZ
315D 4F          6790            MOV   C,A
315E 3A F4 36    6800 SETARG     LDA   TARG
3161 11 09 00    6810            LXI   D,9
3164 19          6820 SETAL      DAD   D
3165 77          6830            MOV   M,A      * SET PARAM=TARG
3166 0D          6840            DCR   C
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

3167 C2 64 31    6850             JNZ   SETAL
316A C9          6860             RET
316B             6870 *
316B             6880 *  BCWRD
316B             6890 *  MODIFIES N FRAMES BACKWARD FROM AND INCLUDING
316B             6900 *  FRAME I, CURRENTLY INDICATED BY HL.
316B             6910 *  B CONTAINS THE NUMBER N
316B             6920 *  LOCATION BVAL CONTAINS THE FINAL DESIRED VALUE
316B             6930 *  FOR FRAME I (THE LAST ONE MODIFIED).
316B             6940 *  ON RETURN, HL IS LEFT POINTING TO THE PARAM, FRAME I
316B             6950 *
316B 78          6960 BCWRD       MOV   A,B      * CHECK N
316C FE 02       6970             CPI   2
316E D8          6980             RC
316F CA CD 31    6990             JZ    SETIB    * MODIFY ONLY THE LAST FRAME
3172 87          7000             ADD   A
3173 87          7010             ADD   A
3174 87          7020             ADD   A
3175 80          7030             ADD   B
3176 2F          7040             CMA
3177 5F          7050             MOV   E,A
3178 16 FF       7060             MVI   D,255
317A 13          7070             INX   D        * DE = -9*N
317B 19          7080             DAD   D
317C 56          7090             MOV   D,M      * GET YO, VALUE AT FRAME I-N
317D E5          7100             PUSH  H
317E D5          7110             PUSH  D
317F 3A F5 36    7120             LDA   BVAL
3182 92          7130             SUB   D
3183 F5          7140             PUSH  PSW      * PUT SIGN(BVAL-YO) IN STACK
3184 D2 89 31    7150             JNC   $+5
3187 2F          7160             CMA
3188 3C          7170             INR   A
3189 6F          7180             MOV   L,A
318A 26 00       7190             MVI   H,0
318C 29          7200             DAD   H        * 2*ABS(BVAL-YO), SIGN IN STK
318D 29          7210             DAD   H        *    ... *16
318E 29          7220             DAD   H
318F 29          7230             DAD   H
3190 29          7240             DAD   H
3191 58          7250             MOV   E,B
3192 1C          7260             INR   E
3193 CD 03 32    7270             CALL  MUL      * COMPUTE (DE)=N*(N+1)
3196 EB          7280             XCHG
3197 CD 13 32    7290             CALL  DIV      * COMPUTE 16*SECOND DIFF
319A F1          7300             POP   PSW
319B D2 A5 31    7310             JNC   BCW3
319E 7C          7320             MOV   A,H
319F 2F          7330             CMA
31A0 67          7340             MOV   H,A
31A1 7D          7350             MOV   A,L
31A2 2F          7360             CMA
31A3 6F          7370             MOV   L,A
31A4 23          7380             INX   H
31A5 29          7390 BCW3        DAD   H
31A6 29          7400             DAD   H
31A7 29          7410             DAD   H
```

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ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

31A8 29             7420             DAD   H
31A9 22 F6 36       7430             SHLD  SD         * SD=256*SECOND DIFF
31AC D1             7440             POP   D          * GET Y0 VALUE BACK
31AD 1E 00          7450             MVI   E,0        * (DE)=256*Y0
31AF 78             7460             MOV   A,B        * LOOP COUNT IS N-1
31B0 3D             7470             DCR   A
31B1 01 00 00       7480             LXI   B,0        * INIT DELTA=0
31B4 2A F6 36       7490 BCWLP       LHLD  SD
31B7 09             7500             DAD   B
31B8 44             7510             MOV   B,H        * DELTA=DELTA+SD INTO BC
31B9 4D             7520             MOV   C,L
31BA 19             7530             DAD   D          * Y=Y+DELTA
31BB D1             7540             POP   D
31BC E5             7550             PUSH  H
31BD 21 09 00       7560             LXI   H,9
31C0 19             7570             DAD   D          * NEW ADDR=ADDR+9
31C1 D1             7580             POP   D
31C2 E5             7590             PUSH  H
31C3 72             7600             MOV   M,D
31C4 3D             7610             DCR   A
31C5 C2 B4 31       7620             JNZ   BCWLP
31C8 D1             7630             POP   D          * CLEAN UP THE STACK
31C9 11 09 00       7640             LXI   D,9
31CC 19             7650             DAD   D
31CD 3A F5 36       7660 SETIB       LDA   BVAL       * PUT BVAL IN LAST FRAME
31D0 77             7670             MOV   M,A
31D1 C9             7680             RET
31D2                7690 *
31D2                7700 *   MULPC
31D2                7710 *   MULTIPLY ABS(A) BY PC, SIGN(A) IS IN CARRY
31D2                7720 *   POSSIBLE VALUES OF PC ARE 0,1/4,1/2,3/4, & 1
31D2                7730 *   STORED WITH THE BIN PT TO THE RIGHT OF BIT 2
31D2                7740 *   RETURN RESULT IN A
31D2                7750 *    (DE) LOST, (BC) & (HL) RESTORED
31D2                7760 *
31D2 E5             7770 MULPC       PUSH  H
31D3 1E 00          7780             MVI   E,0
31D5 D2 DB 31       7790             JNC   MPC1       * IF CARRY SET, ...
31D8 2F             7800             CMA
31D9 3C             7810             INR   A          * COMPL A, SAVE CARRY IN E
31DA 1D             7820             DCR   E
31DB 6F             7830 MPC1        MOV   L,A
31DC 3A F3 36       7840             LDA   PC
31DF 1F             7850             RAR
31E0 67             7860             MOV   H,A
31E1 3E 00          7870             MVI   A,0
31E3 D2 E8 31       7880             JNC   MPC2
31E6 85             7890             ADD   L
31E7 1F             7900             RAR
31E8 57             7910 MPC2        MOV   D,A
31E9 7C             7920             MOV   A,H
31EA 1F             7930             RAR
31EB 67             7940             MOV   H,A
31EC 7A             7950             MOV   A,D
31ED D2 F2 31       7960             JNC   MPC3
31F0 85             7970             ADD   L
31F1 1F             7980             RAR
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

31F2 57           7990 MPC3       MOV   D,A
31F3 7C           8000            MOV   A,H
31F4 1F           8010            RAR
31F5 7A           8020            MOV   A,D
31F6 D2 FA 31     8030            JNC   MPC4
31F9 85           8040            ADD   L
31FA E1           8050 MPC4       POP   H
31FB 1C           8060            INR   E
31FC C0           8070            RNZ
31FD 2F           8080            CMA
31FE 3C           8090            INR   A         * RESTORE SIGN OF A
31FF C9           8100            RET
3200              8110 *
3200              8120 *  MUL SUBROUTINE
3200              8130 *  MULTIPLY (B) BY (E), 16 BIT RESULT IN DE
3200              8140 *    SEE INTEL ASSY LANG PROG MAN., PAGE 54
3200              8150 *    HL NOT DISTURBED
3200              8160 *
3200 16 00        8170 MUL        MVI   D,0
3202 0E 09        8180            MVI   C,9
3204 7B           8190 MUL2       MOV   A,E
3205 1F           8200            RAR
3206 5F           8210            MOV   E,A
3207 0D           8220            DCR   C
3208 C8           8230            RZ
3209 7A           8240            MOV   A,D
320A D2 0E 32     8250            JNC   MUL3
320D 80           8260            ADD   B
320E 1F           8270 MUL3       RAR
320F 57           8280            MOV   D,A
3210 C3 04 32     8290            JMP   MUL2
3213              8300 *
3213              8310 *  DIV SUBROUTINE
3213              8320 *  DIVIDE (DE)/(HL), RRESULT IN HL, REM IN DE
3213              8330 *    BC RESTORED, A DESTROYED
3213              8340 *
3213 C5           8350 DIV        PUSH  B
3214 44           8360            MOV   B,H
3215 4D           8370            MOV   C,L
3216 21 00 00     8380            LXI   H,0
3219 3E 10        8390            MVI   A,16
321B F5           8400 DIV1       PUSH  PSW
321C 29           8410            DAD   H
321D EB           8420            XCHG
321E 29           8430            DAD   H
321F EB           8440            XCHG
3220 D2 24 32     8450            JNC   DIV2
3223 23           8460            INX   H
3224 7D           8470 DIV2       MOV   A,L
3225 91           8480            SUB   C
3226 6F           8490            MOV   L,A
3227 7C           8500            MOV   A,H
3228 98           8510            SBB   B
3229 67           8520            MOV   H,A
322A 13           8530            INX   D
322B D2 30 32     8540            JNC   DIV3
322E 09           8550            DAD   B
```

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ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

322F 1B          8560             DCX   D
3230 F1          8570 DIV3        POP   PSW
3231 3D          8580             DCR   A
3232 C2 1B 32    8590             JNZ   DIV1
3235 C1          8600             POP   B
3236 EB          8610             XCHG
3237 C9          8620             RET
3238             8630 *
3238             8640 *  PLOSC TABLE
3238             8650 *  PLOSIVE BURST  PULSE DURATIONS
3238             8660 *
3238 01          8670 PLOSC       DB    1     * P
3239 01          8680             DB    1     * T
323A 02          8690             DB    2     * K
323B 02          8700             DB    2     * KX
323C 01          8710             DB    1     * B
323D 01          8720             DB    1     * D
323E 02          8730             DB    2     * G
323F 02          8740             DB    2     * GX
3240             8750 *
3240             8760 *  END OF SECT 5
```

```
                                                                PAGE 01

ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

2000            0010 *   PLAY ROUTINE, TARGET TABLES, & MISC
2000            0020 *
2000            0030 *   SECTION 6 OF THE CSR1 SYNTHESIS BY RULE SYSTEM
2000            0040 *
2000            0050 *   LLOYD RICE,  COMPUTALKER CONSULTANTS
2000            0060 *   VERSION 1.08   MAY 30, 1977
2000            0070 *
2000            0080 **********
2000            0090 *
2000            0100 *   COMMON JUMP ADDRESS TABLE
2000            0110 *
2000            0120 COMJMP      EQU   $
2000            0130 *
2000            0140 CSR1        DS    3
2003 C3 50 32   0150             JMP   PLAY
2006            0160 BUFADR      DS    2
2008            0170 BUFEND      DS    2
200A            0180 PVTAB       DS    2
200C            0190 MATPAK      DS    3
200F            0200 MATERR      DS    3
2012            0210 RULES       DS    3
2015            0220 SETDUR      DS    3
2018            0230 RULES3      DS    3
201B            0240 GENF0       DS    3
201E            0250 CLRBUF      DS    3
2021            0260 GENPRM      DS    3
2024            0270 MUL         DS    3
2027            0280 DIV         DS    3
202A C3 96 32   0290             JMP   GETCNS
202D C3 D0 32   0300             JMP   PCBFT
2030 1C 33      0310             DW    F1TAR
2032 58 33      0320             DW    F2TAR
2034 94 33      0330             DW    F3TAR
2036 D0 33      0340             DW    AVHTAR
2038 CC 34      0350             DW    FRNTAR
203A            0360 *
203A            0370 **********
203A            0380 *
203A            0390 *   COMRAM ORIGEN DEFINITION
203A            0400 *
203A            0410             ORG   COMJMP+1500H
3500            0420 COMRAM      EQU   $
3500            0430 *
3500            0440 *   CSR1 SYSTEM RAM SPACE DEFINITION
3500            0450 *
3500            0460 MATPTR      DS    2
3502            0470 NEGEND      DS    2
3504            0480 MATRIX      EQU   $
3504            0490 MATLEN      EQU   95
3504            0500 PHCODE      DS    MATLEN
3563            0510 FEATA       DS    MATLEN
35C2            0520 FEATB       DS    MATLEN
3621            0530 STRES       DS    MATLEN
3680            0540 DUR         DS    MATLEN
36DF            0550 MATEND      EQU   $
36DF            0560 BUFPTR      DS    2
36E1            0570 *
```

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ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

36E1            0580 *  THE NEXT 19 LOCATIONS ARE USED IN COMMON
36E1            0590 *  WITH SECTION 5.  THEY MUST NOT BE MOVED
36E1            0600 *
36E1            0610 OCODE      DS    1
36E2            0620 OFEATA     DS    1
36E3            0630 OFEATB     DS    1
36E4            0640 ODUR       DS.   1
36E5            0650 OCID       DS    1
36E6            0660 ORANK      DS    1
36E7            0670 OPCT       DS    1
36E8            0680 OTIMES     DS    1
36E9            0690 *
36E9            0700 CODEX      DS    1
36EA            0710 FEATAX     DS    1
36EB            0720 FEATBX     DS    1
36EC            0730 DURX       DS    1
36ED            0740 CIDX       DS.   1
36EE            0750 RANKX      DS    1
36EF            0760 PCTX       DS    1
36F0            0770 TIMESX     DS    1
36F1            0780 *
36F1            0790 BT         DS    1
36F2            0800 FT         DS    1
36F3            0810 PC         DS    1
36F4            0820 *
36F4            0830 **********
36F4            0840 *
36F4            0850 *  PLAY (LOCAL) RAM WORKSPACE
36F4            0860 *
36F4            0870 CTO        DS    3        * SPACE FOR CT-1 OUTPUT CODE
36F7            0880 *
36F7            0890 **********
36F7            0900 *
36F7            0910            ORG   COMJMP+1250H
3250            0920 SECTAD     EQU   $
3250            0930 *
3250            0940 *
3250            0950 *  DEFINITIONS FOR PLAY SUBROUTINE
3250            0960 *
3250            0970 CTBASE     EQU   0E0H
3250            0980 CHANSW     EQU   15
3250            0990 *
3250            1000 **********
3250            1010 *
3250            1020 *  PLAYBACK SUBROUTINE
3250            1030 *
3250 21 F4 36   1040 PLAY       LXI   H,CTO    * SETUP CT-1 OUTPUT SUBROUTINE
3253 36 D3      1050            MVI   M,0D3H
3255 23         1060            INX   H
3256 23         1070            INX   H
3257 36 C9      1080            MVI   M,0C9H   * SETUP RETURN
3259 2A 06 20   1090            LHLD  BUFADR
325C 5E         1100            MOV   E,M      * GET FRAME COUNT (LOW BYTE)
325D 23         1110            INX   H
325E 56         1120            MOV   D,M      *  (AND HIGH BYTE)
325F 23         1130            INX   H
3260 CD 77 32   1140            CALL  CTOUT    * SET CT-1 PARAMS FROM FRAME 1
```

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ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

3263 1B          1150            DCX   D         * COUNT THAT FRAME
3264 3E FF       1160            MVI   A,255
3266 D3 EF       1170            OUT   CTBASE+CHANSW * TURN ON CT-1
3268 CD 77 32    1180 PLALP      CALL  CTCUT     * PLAY THE BUFFER
326B CD 8A 32    1190            CALL  DLY10     * WAIT 10 MSEC
326E 1B          1200            DCX   D
326F 7A          1210            MOV   A,D
3270 B3          1220            ORA   E
3271 C2 68 32    1230            JNZ   PLALP     * LOOP UNTIL BUFFER DONE
3274 D3 EF       1240            OUT   CTBASE+CHANSW * TURN OFF CT-1
3276 C9          1250            RET
3277             1260 *
3277             1270 *  CTOUT PLAYS ONE DATA FRAME FROM THE BUFFER
3277             1280 *  ON ENTRY: HL POINTS TO AV OF THE FRAME TO PLAY
3277             1290 *            SUBR CTO HAS BEEN SET UP AS:
3277             1300 *                   CTO   OUT CTBASE
3277             1310 *                         RET
3277             1320 *  (DE) ARE UNCHANGED
3277             1330 *
3277 06 EC       1340 CTCUT      MVI   B,CTBASE * RE-INITIALIZE CTO ROUTINE
3279 0E 09       1350            MVI   C,9
327B 78          1360 CTLP       MOV   A,B
327C 32 F5 36    1370            STA   CTO+1
327F 7E          1380            MOV   A,M
3280 CD F4 36    1390            CALL  CTO       * OUTPUT THE PARAMETER
3283 23          1400            INX   H
3284 04          1410            INR   B
3285 0D          1420            DCR   C
3286 C2 7B 32    1430            JNZ   CTLP      * GO AROUND 9 TIMES
3289 C9          1440            RET
328A             1450 *
328A             1460 *  DELAY 10 MILLISECONDS (ASSUMES 2MHZ CLOCK)
328A             1470 *  (A) CHANGED, ALL ELSE RESTORED
328A             1480 *
328A E5          1490 DLY10      PUSH  H
328B 21 20 03    1500            LXI   H,800
328E 2B          1510            DCX   H
328F 7C          1520            MOV   A,H
3290 B5          1530            ORA   L
3291 C2 8E 32    1540            JNZ   $-3
3294 E1          1550            POP   H
3295 C9          1560            RET
3296             1570 *
3296             1580 **********
3296             1590 *
3296             1600 *  GETCNS SUBROUTINE
3296             1610 *  GET MISC CONSTANTS PERTAINING TO THE CURRENT PHON
3296             1620 *  PUT DATA INTO TABLE BEGINNING AT (DE)
3296             1630 *     ALL REGISTERS MODIFIED
3296             1640 *
3296 2A 00 35    1650 GETCNS     LHLD  MATPTR
3299 01 5F 00    1660            LXI   B,MATLEN
329C 7E          1670            MOV   A,M       * GET CURRENT PHON CODE
329D 12          1680            STAX  D
329E 09          1690            DAD   B
329F 13          1700            INX   D
32A0 7E          1710            MOV   A,M       * GET FEATA
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

32A1 12         1720             STAX  D
32A2 09         1730             DAD   B
32A3 13         1740             INX   D
32A4 7E         1750             MOV   A,M       * GET FEATB
32A5 12         1760             STAX  D
32A6 09         1770             DAD   B
32A7 09         1780             DAD   B
32A8 13         1790             INX   D
32A9 7E         1800             MOV   A,M       * GET DURATION
32AA 12         1810             STAX  D
32AB 13         1820             INX   D
32AC 2A 00 35   1830             LHLD  MATPTR    * GET CODE AGAIN
32AF 4E         1840             MOV   C,M
32B0 06 00      1850             MVI   B,0
32B2 21 48 34   1860             LXI   H,RAPCID
32B5 09         1870             DAD   B
32B6 7E         1880             MOV   A,M       * GET RANK/PC/ID BYTE
32B7 6F         1890             MOV   L,A
32B8 E6 07      1900             ANI   7
32BA 12         1910             STAX  D         * MASK & STORE CID
32BB 13         1920             INX   D
32BC 60         1930             MOV   H,B
32BD 29         1940             DAD   H
32BE 29         1950             DAD   H
32BF 29         1960             DAD   H
32C0 7C         1970             MOV   A,H
32C1 12         1980             STAX  D         * STORE RANK
32C2 13         1990             INX   D
32C3 60         2000             MOV   H,B
32C4 29         2010             DAD   H
32C5 29         2020             DAD   H
32C6 7C         2030             MOV   A,H
32C7 12         2040             STAX  D         * SHIFT & STORE PERCENT
32C8 13         2050             INX   D
32C9 21 84 34   2060             LXI   H,TTIMES
32CC 09         2070             DAD   B
32CD 7E         2080             MOV   A,M       * GET TRANSITION TIMES BYTE
32CE 12         2090             STAX  D
32CF C9         2100             RET
32D0            2110 *
32D0            2120 *  PCBFT SUBROUTINE
32D0            2130 *  GET PERCENT AND TIME VALUES FROM MATRIX ARRAYS
32D0            2140 *   SET PC=PCVF(CIDX,OCID)
32D0            2150 *   SET BT=TAVF(OCID)
32D0            2160 *   SET FT=TAVF(CIDX)
32D0            2170 *  ON ENTRY: B=0 TO GET AV/AH INFO
32D0            2180 *            B#0 TO GET AF INFO
32D0            2190 *
32D0 3A E5 36   2200 PCBFT       LDA   OCID
32D3 4F         2210             MOV   C,A
32D4 87         2220             ADD   A
32D5 81         2230             ADD   C
32D6 87         2240             ADD   A
32D7 81         2250             ADD   C
32D8 57         2260             MOV   D,A
32D9 3A ED 36   2270             LDA   CIDX
32DC 82         2280             ADD   D
```

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ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

32DD 5F           2290              MOV   E,A
32DE 16 00        2300              MVI   D,0       * PCVF INDEX IS 7*OCID+CIDX
32E0 21 C0 34     2310              LXI   H,PCVF
32E3 19           2320              DAD   D
32E4 AF           2330              XRA   A
32E5 B0           2340              ORA   B
32E6 7E           2350              MOV   A,M
32E7 CA ED 32     2360              JZ    $+6       * KEEP AV/AH PC VALUE
32EA 1F           2370              RAR
32EB 1F           2380              RAR
32EC 1F           2390              RAR   *         * SHIFT OVER TO AF PC VALUE
32ED E6 07        2400              ANI   7
32EF 32 F3 36     2410              STA   PC        * STORE PERCENT VALUE
32F2 59           2420              MOV   E,C       * USE OLD CID AS TIME TABLE INDEX
32F3 21 F1 34     2430              LXI   H,TAVF
32F6 EB           2440              XCHG
32F7 19           2450              DAD   D
32F8 AF           2460              XRA   A
32F9 B0           2470              ORA   B
32FA 7E           2480              MOV   A,M
32FB CA 01 33     2490              JZ    $+6       * KEEP AV TIME CONSTANTS
32FE 1F           2500              RAR
32FF 1F           2510              RAR
3300 1F           2520              RAR   *         * SHIFT OVER TO AF CONSTANTS
3301 E6 07        2530              ANI   7
3303 32 F1 36     2540              STA   BT        * STORE BACKWARD TIME CONSTANT
3306 3A ED 36     2550              LDA   CIDX
3309 6F           2560              MOV   L,A
330A 26 00        2570              MVI   H,0       * USE NEW CID TO INDEX TAVF
330C 19           2580              DAD   D
330D AF           2590              XRA   A
330E B0           2600              ORA   B
330F 7E           2610              MOV   A,M
3310 CA 16 33     2620              JZ    $+6
3313 1F           2630              RAR
3314 1F           2640              RAR
3315 1F           2650              RAR
3316 E6 07        2660              ANI   7
3318 32 F2 36     2670              STA   FT        * STORE FORWARD TIME CONST.
331B C9           2680              RET
331C              2690 *
331C              2700 *  F1 TARGET TABLE
331C              2710 *
331C 00           2720 F1TAR        DB    0     * SPACE
331D 00           2730              DB    0     * PERIOD
331E 80           2740              DB    128   * COMMA (PAUSE)
331F 00           2750              DB    0     * QUEST
3320 00           2760              DB    0     * # (TERMINATOR)
3321 B6           2770              DB    182   * IY
3322 93           2780              DB    147   * IH
3323 71           2790              DB    113   * EH
3324 58           2800              DB    88    * AE
3325 55           2810              DB    85    * AA
3326 67           2820              DB    103   * AH
3327 6D           2830              DB    109   * AO
3328 77           2840              DB    119   * OW
3329 95           2850              DB    149   * UH
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

332A A8           2860            DB    168   * UW
332B 48           2870            DB    72    * AX
332C 88           2880            DB    136   * IX
332D 8D           2890            DB    141   * ER
332E AF           2900            DB    175   * UX
332F 77           2910            DB    119   * OH
3330 55           2920            DB    85    * AW
3331 55           2930            DB    85    * AY
3332 6D           2940            DB    109   * OY
3333 71           2950            DB    113   * EY
3334 8D           2960            DB    141   * RX
3335 95           2970            DB    149   * LX
3336 AB           2980            DB    171   * WX
3337 98           2990            DB    152   * YX
3338 A5           3000            DB    165   * WH
3339 00           3010            DB    0     * EL
333A 00           3020            DB    0     * EM
333B 00           3030            DB    0     * EN
333C A8           3040            DB    168   * R
333D A2           3050            DB    162   * L
333E B3           3060            DB    179   * W
333F C2           3070            DB    194   * Y
3340 EF           3080            DB    239   * M
3341 EF           3090            DB    239   * N
3342 EF           3100            DB    239   * NX
3343 BE           3110            DB    190   * P
3344 BE           3120            DB    190   * T
3345 BE           3130            DB    190   * K
3346 BE           3140            DB    190   * KX
3347 BE           3150            DB    190   * B
3348 BE           3160            DB    190   * D
3349 BE           3170            DB    190   * G
334A BE           3180            DB    190   * GX
334B BE           3190            DB    190   * DX
334C BE           3200            DB    190   * F
334D BE           3210            DB    190   * TH
334E BE           3220            DB    190   * S
334F BE           3230            DB    190   * SH
3350 BE           3240            DB    190   * V
3351 BE           3250            DB    190   * DH
3352 BE           3260            DB    190   * Z
3353 BE           3270            DB    190   * ZH
3354 00           3280            DB    0     * CH
3355 00           3290            DB    0     * JH
3356 80           3300            DB    128   * HH
3357 80           3310            DB    128   * Q
3358              3320 *
3358              3330 *  F2 TARGET TABLE
3358              3340 *
3358 00           3350 F2TAR      DB    0     * SPACE
3359 00           3360            DB    0     * PERIOD
335A 80           3370            DB    128   * COMMA (PAUSE)
335B 00           3380            DB    0     * QUEST
335C 00           3390            DB    0     * # (TERMINATOR)
335D 58           3400            DB    88    * IY
335E 6A           3410            DB    106   * IH
335F 75           3420            DB    117   * EH
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

3360 71         3430            DB    113   * AE
3361 96         3440            DB    150   * AA
3362 A0         3450            DB    160   * AH
3363 B3         3460            DB    179   * AO
3364 C2         3470            DB    194   * OW
3365 B6         3480            DB    182   * UH
3366 9B         3490            DB    155   * UW
3367 A0         3500            DB    160   * AX
3368 79         3510            DB    121   * IX
3369 92         3520            DB    146   * ER
336A 8D         3530            DB    141   * UX
336B C2         3540            DB    194   * OH
336C 96         3550            DB    150   * AW
336D 96         3560            DB    150   * AY
336E B3         3570            DB    179   * OY
336F 6A         3580            DB    106   * EY
3370 8D         3590            DB    141   * EX
3371 B1         3600            DB    177   * LX
3372 CC         3610            DB    204   * WX
3373 64         3620            DB    100   * YX
3374 CC         3630            DB    204   * WH
3375 00         3640            DB    0     * EL
3376 00         3650            DB    0     * EM
3377 00         3660            DB    0     * EN
3378 B1         3670            DB    177   * R
3379 B8         3680            DB    184   * L
337A DC         3690            DB    220   * W
337B 64         3700            DB    100   * Y
337C BE         3710            DB    190   * M
337D 79         3720            DB    121   * N
337E 6A         3730            DB    106   * NX
337F BE         3740            DB    190   * P
3380 79         3750            DB    121   * T
3381 4D         3760            DB    77    * K
3382 8D         3770            DB    141   * KX
3383 BE         3780            DB    190   * B
3384 79         3790            DB    121   * D
3385 4D         3800            DB    77    * G
3386 8D         3810            DB    141   * GX
3387 79         3820            DB    121   * DX
3388 BE         3830            DB    190   * F
3389 80         3840            DB    128   * TH
338A 92         3850            DB    146   * S
338B 5E         3860            DB    94    * SH
338C BE         3870            DB    190   * V
338D 80         3880            DB    128   * DH
338E 92         3890            DB    146   * Z
338F 5E         3900            DB    94    * ZH
3390 00         3910            DB    0     * CH
3391 00         3920            DB    0     * JH
3392 80         3930            DB    128   * HH
3393 80         3940            DB    128   * ?
3394            3950 *
3394            3960 *  F3 TARGET TABLE
3394            3970 *
3394 00         3980 F3TAR      DB    0     * SPACE
3395 00         3990            DB    0     * PERIOD
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

3396 AC          4000             DB    172   * COMMA (PAUSE)
3397 00          4010             DB    0     * QUEST?
3398 00          4020             DB    0     * # (TERMINATOR)
3399 84          4030             DB    132   * IY
339A A7          4040             DB    167   * IH
339B B0          4050             DB    176   * EH
339C B5          4060             DB    181   * AE
339D 9B          4070             DB    155   * AA
339E 9F          4080             DB    159   * AH
339F AC          4090             DB    172   * AO
33A0 C8          4100             DB    200   * OW
33A1 BE          4110             DB    190   * UH
33A2 BE          4120             DB    190   * UW
33A3 A3          4130             DB    163   * AX
33A4 B5          4140             DB    181   * IX
33A5 FF          4150             DB    255   * ER
33A6 BE          4160             DB    190   * UX
33A7 C8          4170             DB    200   * OH
33A8 9B          4180             DB    155   * AW
33A9 9B          4190             DB    155   * AY
33AA AC          4200             DB    172   * OY
33AB B0          4210             DB    176   * EY
33AC FF          4220             DB    255   * RX
33AD 8B          4230             DB    139   * LX
33AE C8          4240             DB    200   * WX
33AF AC          4250             DB    172   * YX
33B0 B9          4260             DB    185   * WH
33B1 00          4270             DB    0     * EL
33B2 00          4280             DB    0     * EM
33B3 00          4290             DB    0     * EN
33B4 FF          4300             DB    255   * R
33B5 88          4310             DB    136   * L
33B6 B9          4320             DB    185   * W
33B7 84          4330             DB    132   * Y
33B8 DC          4340             DB    220   * M
33B9 A3          4350             DB    163   * N
33BA F3          4360             DB    243   * NX
33BB DC          4370             DB    220   * P
33BC A3          4380             DB    163   * T
33BD AC          4390             DB    172   * K
33BE FF          4400             DB    255   * KX
33BF DC          4410             DB    220   * B
33C0 A3          4420             DB    163   * D
33C1 AC          4430             DB    172   * G
33C2 FF          4440             DB    255   * GX
33C3 A3          4450             DB    163   * DX
33C4 D2          4460             DB    210   * F
33C5 9B          4470             DB    155   * TH
33C6 A7          4480             DB    167   * S
33C7 9B          4490             DB    155   * SH
33C8 D2          4500             DB    210   * V
33C9 9B          4510             DB    155   * DH
33CA A7          4520             DB    167   * Z
33CB 9B          4530             DB    155   * ZH
33CC 00          4540             DB    0     * CH
33CD 00          4550             DB    0     * JH
33CE AC          4560             DB    172   * HH
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

33CF AC           4570            DB    172   * Q
33D0              4580 *
33D0              4590 *  AV/AH TARGET TABLE
33D0              4600 *
33D0 00           4610 AVHTAR     DB    0     * SPACE
33D1 00           4620            DB    0     * PERIOD
33D2 00           4630            DB    0     * COMMA (PAUSE)
33D3 00           4640            DB    0     * QUEST
33D4 00           4650            DB    0     * # (TERMINATOR)
33D5 E0           4660            DB    224   * IY
33D6 E0           4670            DB    224   * IH
33D7 E0           4680            DB    224   * EH
33D8 E0           4690            DB    224   * AE
33D9 E0           4700            DB    224   * AA
33DA E0           4710            DB    224   * AH
33DB E0           4720            DB    224   * AO
33DC E0           4730            DB    224   * OW
33DD E0           4740            DB    224   * UH
33DE E0           4750            DB    224   * UW
33DF E0           4760            DB    224   * AX
33E0 E0           4770            DB    224   * IX
33E1 E0           4780            DB    224   * ER
33E2 E0           4790            DB    224   * UX
33E3 E0           4800            DB    224   * OH
33E4 E0           4810            DB    224   * AW
33E5 E0           4820            DB    224   * AY
33E6 E0           4830            DB    224   * OY
33E7 E0           4840            DB    224   * EY
33E8 E0           4850            DB    224   * RX
33E9 E0           4860            DB    224   * LX
33EA E0           4870            DB    224   * WX
33EB E0           4880            DB    224   * YX
33EC EA           4890            DB    234   * WH
33ED 00           4900            DB    0     * EL
33EE 00           4910            DB    0     * EM
33EF 00           4920            DB    0     * EN
33F0 A0           4930            DB    160   * R
33F1 A0           4940            DB    160   * L
33F2 A0           4950            DB    160   * W
33F3 A0           4960            DB    160   * Y
33F4 A0           4970            DB    160   * M
33F5 A0           4980            DB    160   * N
33F6 A0           4990            DB    160   * NX
33F7 00           5000            DB    0     * P
33F8 00           5010            DB    0     * T
33F9 00           5020            DB    0     * K
33FA 00           5030            DB    0     * KX
33FB 40           5040            DB    64    * B
33FC 40           5050            DB    64    * D
33FD 40           5060            DB    64    * G
33FE 40           5070            DB    64    * GX
33FF 00           5080            DB    0     * DX
3400 00           5090            DB    0     * F
3401 00           5100            DB    0     * TH
3402 05           5110            DB    5     * S
3403 08           5120            DB    8     * SH
3404 E0           5130            DB    224   * V
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

3405 E0             5140             DB    224    * DH
3406 E5             5150             DB    229    * Z
3407 E8             5160             DB    232    * ZH
3408 00             5170             DB    0      * CH
3409 00             5180             DB    0      * JH
340A 0A             5190             DB    10     * HH
340B 80             5200             DB    128    * Q
340C                5210 *
340C                5220 *  FF/AF/AN TARGET TABLE
340C                5230 *
340C 80             5240 FRNTAR      DB    128    * SPACE
340D 80             5250             DB    128    * PERIOD
340E 80             5260             DB    128    * COMMA (PAUSE)
340F 80             5270             DB    128    * QUESTT
3410 80             5280             DB    128    * $ (TERMINATOR)
3411 80             5290             DB    128    * IY
3412 80             5300             DB    128    * IH
3413 80             5310             DB    128    * EH
3414 80             5320             DB    128    * AE
3415 80             5330             DB    128    * AA
3416 80             5340             DB    128    * AH
3417 80             5350             DB    128    * AO
3418 80             5360             DB    128    * OW
3419 80             5370             DB    128    * UH
341A 80             5380             DB    128    * UW
341B 80             5390             DB    128    * AX
341C 80             5400             DB    128    * IX
341D 80             5410             DB    128    * ER
341E 80             5420             DB    128    * UX
341F 80             5430             DB    128    * OH
3420 80             5440             DB    128    * AW
3421 80             5450             DB    128    * AY
3422 80             5460             DB    128    * OY
3423 80             5470             DB    128    * EY
3424 80             5480             DB    128    * RX
3425 80             5490             DB    128    * LX
3426 80             5500             DB    128    * WX
3427 80             5510             DB    128    * YX
3428 80             5520             DB    128    * WH
3429 80             5530             DB    128    * EL
342A 80             5540             DB    128    * EM
342B 80             5550             DB    128    * EN
342C 80             5560             DB    128    * R
342D 80             5570             DB    128    * L
342E 80             5580             DB    128    * W
342F 80             5590             DB    128    * Y
3430 82             5600             DB    130    * M
3431 82             5610             DB    130    * N
3432 82             5620             DB    130    * NX
3433 80             5630             DB    128    * P
3434 80             5640             DB    128    * T
3435 80             5650             DB    128    * K
3436 80             5660             DB    128    * KX
3437 80             5670             DB    128    * B
3438 80             5680             DB    128    * D
3439 80             5690             DB    128    * G
343A 80             5700             DB    128    * GX
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

343B 80         5710            DB    128  * DX
343C B0         5720            DB    176  * F
343D 70         5730            DB    112  * TH
343E 98         5740            DB    152  * S
343F 74         5750            DB    116  * SH
3440 B0         5760            DB    176  * V
3441 74         5770            DB    116  * DH
3442 98         5780            DB    152  * Z
3443 74         5790            DB    116  * ZH
3444 60         5800            DB    128  * CH
3445 80         5810            DB    128  * JH
3446 80         5820            DB    128  * HH
3447 80         5830            DB    128  * Q
3448            5840 *
3448            5850 *  RANK/PC/ID TABLE
3448            5860 *
3448 00         5870 RAPCID     DB    0   * SPACE
3449 00         5880            DB    0   * PERIOD
344A 80         5890            DB    128 * COMMA (PAUSE)
344B 00         5900            DB    0   * QUEST
344C 00         5910            DB    0   * # (TERMINATOR)
344D 11         5920            DB    17  * IY
344E 11         5930            DB    17  * IH
344F 11         5940            DB    17  * EH
3450 11         5950            DB    17  * AE
3451 11         5960            DB    17  * AA
3452 11         5970            DB    17  * AH
3453 11         5980            DB    17  * AO
3454 11         5990            DB    17  * OW
3455 11         6000            DB    17  * UH
3456 11         6010            DB    17  * UW
3457 11         6020            DB    17  * AX
3458 11         6030            DB    17  * IX
3459 11         6040            DB    17  * ER
345A 11         6050            DB    17  * UX
345B 11         6060            DB    17  * OH
345C 11         6070            DB    17  * AW
345D 11         6080            DB    17  * AY
345E 11         6090            DB    17  * OY
345F 11         6100            DB    17  * EY
3460 11         6110            DB    17  * RX
3461 3E         6120            DB    62  * LX
3462 31         6130            DB    49  * WX
3463 31         6140            DB    49  * YX
3464 3E         6150            DB    62  * WH
3465 00         6160            DB    0   * EL
3466 00         6170            DB    0   * EM
3467 00         6180            DB    0   * EN
3468 3E         6190            DB    62  * R
3469 3E         6200            DB    62  * L
346A 3E         6210            DB    62  * W
346B 3E         6220            DB    62  * Y
346C 53         6230            DB    83  * M
346D 53         6240            DB    83  * N
346E 53         6250            DB    83  * NX
346F 52         6260            DB    82  * P
3470 52         6270            DB    82  * T
```

```
ADDR B1 B2 B3 E LINE  LABEL     OPCD  OPERAND

3471  52           6280           DB    82   * K
3472  52           6290           DB    82   * KX
3473  53           6300           DB    83   * P
3474  53           6310           DB    83   * D
3475  53           6320           DB    83   * G
3476  53           6330           DB    83   * GX
3477  53           6340           DB    83   * DX
3478  7C           6350           DB    124  * F
3479  7C           6360           DB    124  * TH
347A  7C           6370           DB    124  * S
347B  7C           6380           DB    124  * SH
347C  7D           6390           DB    125  * V
347D  7D           6400           DB    125  * DH
347E  7D           6410           DB    125  * Z
347F  7D           6420           DB    125  * ZH
3480  00           6430           DB    0    * CH
3481  00           6440           DB    0    * JH
3482  86           6450           DB    134  * HH
3483  83           6460           DB    131  * Q
3484               6470 *
3484               6480 *  TRANSITION TIMES TABLE
3484               6490 *
3484  00           6500 TTIMES    DB    0    * SPACE
3485  00           6510           DB    0    * PERIOD
3486  0A           6520           DB    10   * COMMA (PAUSE)
3487  00           6530           DB    0    * QUEST
3488  00           6540           DB    0    * # (TERMINATOR)
3489  AA           6550           DB    170  * IY
348A  AA           6560           DB    170  * IH
348B  AA           6570           DB    170  * EH
348C  AA           6580           DB    170  * AE
348D  AA           6590           DB    170  * AA
348E  AA           6600           DB    170  * AH
348F  AA           6610           DB    170  * AO
3490  AA           6620           DB    170  * OW
3491  AA           6630           DB    170  * UH
3492  AA           6640           DB    170  * UW
3493  AA           6650           DB    170  * AX
3494  AA           6660           DB    170  * IX
3495  AA           6670           DB    170  * ER
3496  AA           6680           DB    170  * UX
3497  AA           6690           DB    170  * OH
3498  AA           6700           DB    170  * AW
3499  AA           6710           DB    170  * AY
349A  AA           6720           DB    170  * OY
349B  AA           6730           DB    170  * EY
349C  77           6740           DB    119  * RX
349D  74           6750           DB    116  * LX
349E  AA           6760           DB    170  * WX
349F  AA           6770           DB    170  * YX
34A0  74           6780           DB    116  * WH
34A1  00           6790           DB    0    * EL
34A2  00           6800           DB    0    * EM
34A3  00           6810           DB    0    * EN
34A4  74           6820           DB    116  * R
34A5  74           6830           DB    116  * L
34A6  74           6840           DB    116  * W
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

34A7 74            6850             DB    116  * Y
34A8 60            6860             DB    96   * M
34A9 70            6870             DB    112  * N
34AA 90            6880             DB    144  * NX
34AB 50            6890             DB    80   * P
34AC 70            6900             DB    112  * T
34AD 90            6910             DB    144  * K
34AE 90            6920             DB    144  * KX
34AF 60            6930             DB    96   * B
34B0 70            6940             DB    112  * D
34B1 90            6950             DB    144  * G
34B2 90            6960             DB    144  * GX
34B3 70            6970             DB    112  * DX
34B4 54            6980             DB    84   * F
34B5 54            6990             DB    84   * TH
34B6 54            7000             DB    84   * S
34B7 54            7010             DB    84   * SH
34B8 54            7020             DB    84   * V
34B9 54            7030             DB    84   * DH
34BA 54            7040             DB    84   * Z
34BB 54            7050             DB    84   * ZH
34BC 00            7060             DB    0    * CH
34BD 00            7070             DB    0    * JH
34BE 0A            7080             DB    10   * HH
34BF 0A            7090             DB    10   * Q
34C0               7100 *
34C0               7110 *  AF PC/AV PC ARRAY, PERCENT CFOSSING VALUES
34C0               7120 *  (BITS 3-5)/32 = AF PERCENT BOUNDARY XING VALUE
34C0               7130 *  (BITS 0-2)/4 = AV PERCENT BOUNDARY XING VALUE
34C0               7140 *
34C0 24            7150 PCVP        DB     32+4   * OLD CID=0, NEW CID=0
34C1 09            7160             DB     8+1    * OLD CID=0, NEW CID=1
34C2 00            7170             DB     0      *     "          "   =2
34C3 00            7180             DB     0      *     ETC.
34C4 09            7190             DB     8+1
34C5 09            7200             DB     8+1
34C6 09            7210             DB     8+1
34C7 09            7220             DB     8+1    * OLD CID=1, NEW CID=0
34C8 24            7230             DB     32+4   *           1
34C9 12            7240             DB     16+2                          1
34CA 12            7250             DB     16+2
34CB 12            7260             DB     16+2
34CC 14            7270             DB     16+4
34CD 24            7280             DB     32+4
34CE 00            7290             DB     0      *  OLD =2,  NEW =0
34CF 12            7300             DB     16+2
34D0 24            7310             DB     32+4
34D1 00            7320             DB     0
34D2 12            7330             DB     16+2
34D3 12            7340             DB     16+2
34D4 12            7350             DB     16+2
34D5 00            7360             DB     0      *   3,  0
34D6 12            7370             DB     16+2
34D7 00            7380             DB     0
34D8 24            7390             DB     32+4
34D9 12            7400             DB     16+2
34DA 12            7410             DB     16+2
```

```
ADDR B1 B2 B3 E LINE  LABEL      OPCD  OPERAND

34DB 12          7420            DB    16+2
34DC 09          7430            DB    8+1     *    ETC.
34DD 12          7440            DB    16+2
34DE 12          7450            DB    16+2
34DF 12          7460            DB    16+2
34E0 24          7470            DB    32+4
34E1 24          7480            DB    32+4
34E2 12          7490            DB    16+2
34E3 09          7500            DB    8+1
34E4 14          7510            DB    16+4
34E5 12          7520            DB    16+2
34E6 12          7530            DB    16+2
34E7 22          7540            DB    32+2
34E8 24          7550            DB    32+4
34E9 14          7560            DB    16+4
34EA 09          7570            DB    8+1
34EB 24          7580            DB    32+4
34EC 12          7590            DB    16+2
34ED 12          7600            DB    16+2
34EE 12          7610            DB    16+2
34EF 14          7620            DB    16+4
34F0 24          7630            DB    32+4
34F1             7640 *
34F1             7650 *  AF/AV TRANSITION TIME TABLE
34F1             7660 *  (BITS 3-5)/8 = AF TRANSITION TIME IN FRAMES
34F1             7670 *  (BITS 0-2) = AV TRANSITION TIME IN FRAMES
34F1 00          7680 TAVF        DB    0       * CID=0
34F2 0B          7690             DB    8+3     *  =1
34F3 00          7700             DB    0       *  =2
34F4 00          7710             DB    0       *  =3
34F5 18          7720             DB    24+0    *  =4
34F6 1B          7730             DB    24+3    *  =5
34F7 0B          7740             DB    8+3     *  =6
34F8             7750 *
34F8             7760 *  END OF SECTION 6
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APPENDIX C

P-3 FLEET PILOT QUESTIONNAIRE

This questionnaire has been prepared by a Thesis student in the Aeronautical Engineering Curriculum at the Naval Postgraduate School, Monterey, California. The general topic of the Thesis deals with aircraft warning systems; those in the current state of the art and those proposed for future aircraft. This questionnaire specifically deals with the P-3 Orion aircraft. Part One deals with the current system, its strengths and weaknesses. Part Two is concerned with proposals for future P-3 cockpit designs. Some questions require brief written answers. Please do not spend too much time on these. Incomplete sentence structure is acceptable, just ensure your idea is there. You are also asked to complete the following items that we may have a good idea of your experience level. This does not mean we will ignore "low time JO's", however. A cockpit must be designed to adequately accomodate all experience levels of pilots, and we want to know what each type of pilot feels about the P-3. The name is optional, of course, but would help us to recontact you in the event one of your ideas merits further consideration and/or requires clarification. Also we would like to give credit where it is due. If you have any comments or additional ideas in this area not covered by this questionnaire, please feel free to use any free space for your comments or attach an additional sheet if necessary.

NAME ______________________________

AIRCRAFT QUALIFICATIONS ________________

P-3 QUALIFICATIONS ____________________

PREVIOUS SQUADRON TOURS ________________

FLIGHT TIME IN P-3 ____________________

TOTAL FLIGHT TIME _____________________

PART 1

The questions in this part are concerned with the adequacy of the current instruments/warning systems in the P-3 aircraft.

1. Do you feel that the current instrument/warning system in the P-3 is:

   a) more than adequate?
   b) adequate?
   c) could be improved upon?

2. What, if any, instrument/warning devices would you replace and with what?

3. What additional instruments do you feel would significantly improve the safety and/or instrument flight capabilities of the P-3?

4. How do you feel about the placement of the instruments in the P-3 cockpit?

   a) excellent - no problems with position
   b) acceptable - only a few instruments are inconveniently placed
   c) marginal - many instruments are inconvenient
   d) unacceptable - critical instruments are not readily accessible in certain circumstances

5. If your answer to question 4 was c) or d), please briefly explain your answer. List the instruments in question, and the particular instance when their placement would make them difficult to read.

6. Do you have any other comments concerning the current instrument/warning system in the P-3?

PART 2

The second part of this questionnaire is concerned with possible devices which may be included in future P-3 models.

1. Recognizing the fact that a pilot or flight engineer may be able to gain valuable information from an instrument due to its relative needle position, how do you feel about replacing all dial guages with digital readouts?

   a) don't like the idea - requires each individual guage be read and takes too much time
   b) think its a good idea - like the accuracy of the digital readouts
   c) no opinion either way
   d) other (please explain)

2. Suppose all dial guages were replaced with digital readouts, the numerals of which changed color according to the following code:

   GREEN - normal range
   YELLOW - outside normal range, but still safe
   RED - danger zone

   Now how would you feel about these instruments?

   a) still don't like the idea
   b) didn't like it before, but do now
   c) like the digital readouts, but don't think the color code is necessary
   d) like digital readouts more now because of the color code

3. If a Heads Up Display were proposed for the P-3, what information would you desire it present to: a) the pilot?, b) the copilot?

4. Do you feel the HUD should be projected on the side as well as the forward windshield? Why?

5. Do you feel it would be advantageous to have the HUD incorporate the Master Caution lights (i.e., when a Master Caution light illuminates, it is also repeated on the HUD)?

Assuming that a computer could be designed which would be capable of monitoring all flight systems and parameters (engine performance, pressurization, electrical system, etc.) and be linked to the navigation system so that it would "know" at all times the position of the aircraft, consider the following questions:

6. If the computer could perform certain emergency procedures for the pilot, which would you prefer it be allowed to handle?

7. Which would you not allow the computer to handle under any circumstances?

8. Which would you allow it to perform only with pilot approval (such approval to be given by alphanumeric code or spoken into a microphone)?

9. How would you prefer the computer warn the pilot of impending failures or abnormal readings?

a) by a printed message on a CRT
b) by speaking the message (assume the computer can be made to "talk" in an easily recognizable "voice")
c) both of the above methods
d) other (please explain)

10. How would you feel about a system where the computer had primary control of the landing gear and flap system? Assume that the functions were voice controlled and the computer would not allow gear or flap extension above limit airspeeds. Also assume that the current system remained as a mechanical backup.

a) strongly oppose the concept - too dangerous
b) like the idea - the computer would lower the geat and/or flaps when called for and not miss the call
c) no opinion
d) other (please explain)

11. Would you prefer that the computer be programmed to lower the gear and flaps as the aircraft approached the ground? Assume the system were armed only below 500 feet and when combinations of low airspeed/power settings indicated to the computer that the aircraft was being landed. (Obviously, this is designed to prevent gear up landings. Comments, please.)

a) don't like the idea (Why?)
b) like the idea because it would prevent gear up landings
c) like the idea because it would reduce pilot workload
d) other (please explain)

12. Briefly describe in the following space any ideas you might have concerning cockpit design. Suggestions are specifically requested for improvements in cockpit instrumentation/ warning devices, items which you would like to see delegated to a computer (with or without pilot approval), and anything which would reduce pilot workload in an emergency situation. Also use this space if you did not have enough room to answer any of the previous questions. Be sure to number your answers appropriately.

LIST OF REFERENCES

1. Defense Advanced Research Agency Report, R-1434-ARPA, Military Applications of Speech Understanding Systems, by Hoffman, A., Lippiatt, T., and Turn, R., p. 1-44, June 1974.

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3. Computalker Consultants, CSR1 Theory and Operation Manual, p. 1-4, May 1977.

4. National Aeronautics and Space Administration, Proceedings from the symposium on Voice Technology for Interactive Real-Time Command/Control Systems Application, Ames Research Center, p. 143-165, 6-8 December 1977.

5. Hueristics, Inc., SPEECHLAB Hardware Assembly and Test Manual, p. 3-2 - 3-10.

6. Computalker Consultants, CSR1 Theory and Operation Manual, p. 1, May 1977.

7. SCOPE Electronics, Inc., TECHNICAL REPORT AFAL - TR - 72 - 290, Voice Activated Cockpit Control, Kleiner, Norbert, and Miller, Kenneth, p. 2, p. 7-9, October 1972.

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9. Hueristics, Inc., SPEECHLAB Hardware Assembly and Test Manual, Laboratory Manual, p. 3-75 - 3-95.

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